Second Report

OF

JOINT COMMITTEE

Surveying the Needs of the South Carolina State Development Board

SECOND REPORT OF JOINT COMMITTEE SURVEYING THE NEEDS OF THE SOUTH CAROLINA STATE DEVELOPMENT BOARD

PREFACE

The Committee created under Senate Resolution 63 to survey the needs of the South Carolina State Development Board, continued its work after submitting its initial report to the 1959 General Assembly. This report recommended that this Committee be continued with a view of making a more detailed study of a proper research program and a study of additional methods of providing capital for industrial expansion.

The Committee has spent the greater part of its time and effort in studying the industrial and economic research programs now in existence in our State and in evaluating the need for and importance of additional research facilities and an expanded research program within our State.

In our study of the research phase, we have conferred at length with the presidents and faculties of the University of South Carolina and Clemson College. We have studied the research programs and inspected the research facilities now existing at these two institutions. Both Doctors Sumwalt and Edwards and their respective faculties have been most cooperative and helpful to the Committee in this study. In addition, we have had advice, counsel and assistance from the Governor, members of his Staff and members and staff of the Development Board.

I. WHY RESEARCH?

The Committee's first consideration was an evaluation of the worth of a research program in our State. It was the unanimous feeling of the Committee from the outset that in view of the present demands upon our state budget that no substantial expenditure of state funds could be recommended or justified unless such expenditures would clearly result in either a substantial dollar addition to our economy or material betterments to our methods and standards of living.

The Committee soon recognized that education and research are indispensable elements of a proper industrial expansion program of our state and are equally vital to the health, economic progress and well-being of all our people. As the Committee's study progressed, it became increasingly apparent to us all that a strong, coordinated research program is vital to our state. With such a program, our

state can and will continue its upward climb toward the social and economic goals that its present leaders envision as its potential. Without such a program our progress, if at all, will be slight and we will not keep pace socially, economically or industrially with our sister states.

Proof of the necessity and importance of a program of education and research is abundant. Over two thousand years ago, wise King Solomon is reported to have said "Where there is no vision, the people perish". Economic and social progress in the United States and in South Carolina is the story and record of men of vision, of inquiring minds reaching beyond the frontiers of men's present knowledge asking the questions, first "why" and then "how".

Today, the use of research by industry has become such an important ingredient of progress that research, itself, is being used as a key point in mass marketing and sales efforts. The research which leads to new and more useful products and the research which makes existing products better is widely recognized by consumer product producers as having a strong appeal to potential purchasers.

Anyone who watches television, reads newspaper advertisements, listens to radio or notices billboards along the highways is intimately familiar with the use of the word "research" in consumer selling.

One of the nation's major manufacturers of consumer products ranging from transparent adhesive tape to expensive duplicating equipment advertises that it has a strong products research program and adds: "Research is the key to tomorrow." One major oil company, one of the nation's leading manufacturers and distributors of petroleum products, constantly merchandises its research program as an indication of its up-to-date approach to product development. Still another company, this one a manufacturer of electrical appliances and heavy electrical equipment, tells its consuming public that it offers "Better Living through Research."

Research and education have produced the age of automation. A half century ago, ninety (90%) percent of our country's productive efforts were necessary to produce sufficient food to feed our population. Today ten (10%) percent of our productive effort produces our staple foods.

Technological advances in this age of automation have resulted in new comforts, new leisure, better health, more happiness and longer life for our people. As we enter the nuclear-space age of the 1960's, research points the way to even greater horizons which promise

rich rewards to South Carolina and its citizens if we are willing to make a relatively modest investment of money, time and facilities in an adequate research program.

II. OUR RELATIVE POSITION

One of the reasons that the South has been a retarded economic area has been a lack of a competitive research program. Today in the South, according to the Southern Association of Science and Industry, we have 30% of the population, 23% of the income and only 17% of the research of the nation. As startling and discouraging as these figures are to us as loyal Southerners, we have even more reason to be chagrined when we note the relative position of our State in the South. The expenditure for research in South Carolina is the lowest in the nation. We spent only about two cents of each $100.00 of personal income for research in South Carolina, compared to an average of 7¢ per $100.00 of personal income in 15 other southern and southeastern states.

The expenditure for research in the United States has increased from approximately $1,000,000,000.00 in 1945 to nearly $10,000,000,000.00 at the present time. South Carolina has not kept pace with this increase. It should be noted, however, with considerable pride that the relative accomplishments of South Carolina on its extremely limited research burdget compares favorably with other states where considerably larger sums of money have been expended.

III. PRESENT RESEARCH FACILITIES AND PROGRAMS

1. *General:*

Research at present in the state is confined almost wholly to the University of South Carolina and Clemson College. Other state institutions, as well as our private colleges, apparently do not have the facilities, research personnel or graduate programs necessary for any extensive research programs. It is the Committee's judgment that the proper method of securing a more adequate research program for our state is in stimulating, encouraging and expanding the existing research facilities and personnel at both the University and Clemson.

Research falls generally into two categories: (1) Basic and (2) Applied. Basic research in laymen's terminology might be termed fundamental research or a search for knowledge for knowledge's sake without any immediately apparent practical utilization of the knowledge acquired.

Applied research on the other hand usually has some immediately foreseeable practical value. It should be noted that basic research is ordinarily the forerunner or foundation of applied research, and research of both a basic and applied nature are of equal importance in the over-all picture.

Likewise, for the purpose of this report, we have two main divisions of a research program, namely economic research and technical scientific research, both of which have basic and applied phases.

2. *Economic Research:*

With respect to economic research, this Committee in its initial report recommended as follows:

"With respect to research in the economic field, the Committee notes with approval the work of the Bureau of Business and Economic Research at the University of South Carolina and feels that the expansion of the work of that agency and a closer identification of it with the State Development Board will be an adequate beginning answer to the need for research in this field."

Pursuant to that recommendation, the University has submitted a proposal for the expansion and strengthening of the Bureau of Business and Economic Research of the School of Business Administration. This proposal is attached to this report and marked Exhibit 1.

The Committee feels that the proposal as submitted is sound and that the expansion of the Bureau's functions and services, if approved, will provide (1) information necessary for the successful function and growth of many existing businesses; (2) stimulus to and assistance for new businesses being formed within the state; and (3) essential services for the attraction of new industries to our state.

We anticipate that this expanded program of information and services will be especially valuable in view of the Development Board's action in employing a deputy director charged with assisting existing industries and the promotion and encouraging of new industries within the state.

We understand that the increased budget for the Bureau has been included in the University budget request and has been approved by the Budget and Control Board. The Committee recommends the approval of the expanded program with its budget. The necessity of especially close liaison between the Development Board and this Bureau is essential. It is possible that the Bureau should be established

as an autonomous group in order that this closer liaison may be accomplished.

At Clemson, considerable research is presently conducted within the Agricultural Economics Department. Their efforts include studies on such subjects as marketing, crop reporting and farm economy studies.

The work of this highly experienced group of Clemson economists is vital to the future of our agricultural economy. The Committee feels that their work should be continued and expanded.

3. *Technical-Scientific Research at USC:*

The University of South Carolina formed in 1958 its Institute of Science and Technology which acts both as a guide and as a coordinating agency for research within the University by faculty members of the physical science and engineering departments. The Institute includes in its membership all faculty members of these departments who are interested in research. It operates under an executive committee and four directors who are appointed from the faculty by the President. The Institute also has an advisory board consisting of twelve outstanding business or professional persons not connected with the University.

Some forty-three research projects are currently being conducted by the faculty members of the Institute at the University. A list of these projects with their principal director is attached herewith as Exhibit 2. It should be noted that well over half of the listed projects are being sponsored and financed by private corporations or agencies of the United States government.

Research in the technical-scientific field is being conducted at the University by some thirty-eight faculty members assisted by fifteen full time and forty part time graduate students and twenty-six part time undergraduate students. It should be noted, however, that of the thirty-eight faculty members, none devote full time to research and only six devote as much as half their time to research.

A most encouraging indication of the progress and quality of the University's program is the fact that outside grants and contracts for research totaled $164,850.00 for the year 1958-59, more than triple the amount received in the year 1954-55. Each succeeding year of the last five years has shown a substantial increase in the outside support given this program.

The University has suggested an expansion and improvement of its research program involving an additional expenditure of $255,000-.00. This program and budget is attached herewith as Exhibit 3.

The Committee was much impressed with the interest, enthusiasm and general excellence of the research facilities and personnel of the University, especially in view of the lack of financial contribution from State funds. The faculty, through their interest and initiative in obtaining financial assistance from non-state sources and from their quite evident enthusiasm and competence, demonstrated to the Committee the wisdom of an expanded research effort at University of South Carolina.

4. *Technical-Scientific Research at Clemson:*

The Committee spent a most enlightening two days at Clemson inspecting the research facilities and conferring with President Edwards and the faculty in regard to the present research program and the potential offered at Clemson. The Committee, we are frank to say, was impressed to the point of amazement at the magnitude, quality and results of the research projects which have been and are being conducted at this institution. None of the Committee had any concept of the extent of research being conducted in many varied fields at Clemson. Even more impressive in the Committee's judgment was the exhibited capacity for an enlarged and expanded program which was evident from not only the excellent research facilities but also, and even more important, from capable, dedicated, enthusiastic staff and faculty.

More than 300 research projects are now under way at Clemson. A list of these projects is attached as Exhibit 4. Also included as a part of this exhibit are outlines of areas of projected future research.

It will be noted research being done at Clemson presently embraces the fields of Engineering, Architecture, the Physical Sciences, Textiles and Agriculture. The physical facilities for a continuation and expansion of research in all categories are excellent to superior with a few minor exceptions. A summary of the existing facilities along with a general statement of the major research areas of each particular field is attached as Exhibit 5.

The Committee would like to note especially the ceramic engineering facility and the Chemical Engineering Building, the latter having just been completed. Both of these buildings, together with considerable equipment, were gifts of the Olin Foundation. The value

of these two facilities in dollar terms exceeds $2,000,000.00. Their value to the present and prospective research program of the college and the resulting benefit to the state is incalculable.

An example of the value of the ceramic engineering facility to the industrial development of our state is seen in the fact that one research phase alone resulted in a $3,000,000.00 expansion of a local clay industry. Working with the State Development Board, this Department was a key factor in attracting to the state one of the major manufacturers of plumbing supplies in the nation.

The Olin Foundation has provided not only the buildings, but numerous items of expensive equipment, designed for research purposes. Included, for examples, are a modern electron microscope and a mass spectrometer. The latter, an analytical tool of very high precision, costing more than $60,000.00, is the only one of its kind in the southeastern United States.

The philanthropy of the Olin Foundation is providing these two facilities, the finest obtainable, should be and is a source of satisfaction and gratitude not only to Clemson and the General Assembly, but to the people of the state as well.

It is not practical to comment in the body of this report on the many other fine facilities present at Clemson. As previously stated, a description is included in Exhibit 5. However, we would like to note especially the existence in the Department of Chemistry of one of the finest radioisotope laboratories in the southeast. The Committee believes this facility to be of especial importance and significance in view of the potential existing in the possible peace-time utilization of atomic-nuclear energy which will be commented upon in more detail in a subsequent section of this report.

Clemson has recommended an expanded research program which will entail an additional appropriation of $390,388.00. An itemization of the program and its cost is attached as Exhibit 6.

Included in this request is an appropriation of $55,688.00 for the establishment of an on-campus data processing and computing center including the purchase of the necessary equipment. Such equipment is essential to the research program. The University of South Carolina has this year acquired such equipment.

The Clemson request for $55,688.00 is based on the purchase of computer equipment similar to that owned by the University. It may be that Clemson's data-processing equipment should include a machine of different design, and we understand that a committee of

Clemson researchers is studying this matter. The $55,688.00 figure is a minimum cost for the purchase and operation of an electronic computer installation.

5. *Agricultural Research at Clemson:*

Clemson College has for 67 years been engaged in agricultural research. Prior to the 1950's research at Clemson was in fact virtually confined to the field of agriculture. The program has received substantial support and cooperation from the U. S. Department of Agriculture. The achievements of Clemson in the field of agricultural experimentation and research have been monumental. Millions of dollars in income have been added yearly to the farmers of our state by reason of the knowledge acquired through research in agriculture at Clemson and its experiment stations.

The achievements in the field of agriculture were of especial significance to the Committee for two reasons. First, as noted above, farm income has been increased tremendously through the development of new products, new methods, new insecticides and the rendering of substantial services to farmers such as soil analyses, marketing data, etc. In view of the general crisis and marginal income status which have confronted South Carolina farmers for the last decade, we believe we are justified in concluding and stating that without the research, advice and leadership of Clemson in agriculture for the last decade in our state, farming would be now a lost, possibly bankrupt industry.

The second reason that the Committee considered the agricultural research program significant is that it indicated the tremendous contribution which an adequate research program can make to a given industry. If any proof is needed as to the economic wisdom or justification for research, the agricultural program as conducted at Clemson is such living proof. The investment in this program has been returned many-fold and has been in effect the salvation of what would otherwise have been a sick and dying industry, the passing of which would have produced dire effects upon the entire state's economy. We are attaching herewith as Exhibit 7, a summary of the outstanding research accomplishments in agriculture at Clemson with some staff evaluation of the economic return obtained therefrom. The Committee feels that these evaluations are conservative.

6. *Potential Cooperative Research in Nuclear Energy:*

The Committee jointly with the special committee studying the Peaceful Uses of Nuclear Energy in South Carolina made an inspec-

tion tour of the Savannah River Plant of the Atomic Energy Commission. In addition there has been an interchange of information between the committees with respect to the future benefits of nuclear research to our state.

It is our understanding that the Committee studying the peaceful uses of nuclear energy will detail in its report research potentials in the nuclear-fission field and recommend a coordinated research program.

This Committee wholeheartedly recommends that a major research effort be made by our state in exploiting peace-time uses of nuclear energy. We have at the Savannah River Plant the largest source of nuclear energy suitable for peace-time use to be found anywhere in the world. We have made both at the University and at Clemson an excellent, although modest, beginning in research in this new, challenging and promising field.

Every effort should be made to enlarge and expand research in the nuclear field. These efforts should include a closer liaison with the Atomic Energy Commission and its staff at the Savannah River Plant.

Already in the South a new species of peanuts have been developed through cross-breeding of mutations produced by exposing seed peanuts to massive units of radiation. This new species of peanuts has boosted growers income by approximately $75.00 per acre which means millions of dollars of additional income to the yearly farm economy.

Through the use of radiation the screw worm has been virtually eliminated as a cattle pest which was costing our cattle farmers literally millions of dollars per year.

Possible fields of experiment with nuclear energy include our forest products. A superior, quicker growing pine tree might well result from experiments with radiation. Likewise the application of radiation to our soils may well produce fantastic results in terms of increasing yields per acre, the transformation of substandard, non-producing soil into abundant fertility, and the almost miraculous metamorphosis of some sands and sandy soils into process materials of a high utility value. Already preliminary experiments in radiation as a food preservative give promise of revolutionizing the meat packing and food processing industries. All these possibilities and untold more await the exploitation of more secrets of the atom. A nuclear research program with the initial advantages we have in South Carolina may well put us in the forefront of the nuclear-space age.

7. Implementation of the Program:

As is indicated in the foregoing sections, the Committee feels it vital to our future to initiate without delay an expanded program of research in our state.

Not only will such a program result in tangible benefits and returns such as new products, more efficient methods and the like, but it will also have a secondary, somewhat intangible benefit of almost equal importance. That is the creation of climate or atmosphere which is most attractive to the type of industries which we are seeking to attract in South Carolina. Most progressive industries today recognize research as an integral part of their survival in today's highly competitive society. The proximity of a research center is a major factor in the location of space-age industries. A good example is provided by the electronics industry. M. I. T. and Harvard have made Boston one of the world's big electronic centers. Another almost equally large concentration of electronics is in California where Stanford University is recognized as a leader in this field. An executive of a company located in California recently made this statement:

"Companies can't possibly carry on all the basic research in electronics they need to develop new products. This research is being carried on at Stanford and we retain many of their professors on a consulting basis. When something shakes loose, even if it's at night, they come over and help us."

A similar example in this state is the location of the Saco-Lowell Shops at Clemson. The presence of research programs and academic atmosphere no doubt was one of the more persuasive factors in inducing the company officials to select their site at the Ravenel Research Center overlooking the Clemson Campus.

It is clear therefore that South Carolina today has a challenge which has the ring of a duty . . . to provide state support for a research program, to keep pace with our industrial development program and meet the demands of the nuclear-space decade into which we are now entering.

While the need is vital for a single, coordinated industrial and economic research effort, the Committee is encouraged by the fact that its establishment will entail neither an unstudied crash program nor the expenditure of any excessive amount of money. Already armed with the services, facilities and equipment discussed earlier in this report, South Carolina today can marshal its research forces in

the campaign for an expanded economy largely throught the medium of liaison and coordination.

The Committee has given considerable thought and study as to how such a program can be efficiently coordinated and administered. In this connection, it was heartening to the Committee to see a complete absence of jealousy and an attitude of friendly cooperation between the Presidents and faculties of the University and Clemson. Because of that spirit of friendly cooperation, and a unity and dedication toward the common purpose of serving best the state's interest, the Committee feels it unnecessary and unwise to recommend the creation of a Board with regulatory powers.

The Committee as well as Doctors Sumwalt and Edwards and their faculties recognize the necessity of some group or agency which will provide liaison between the respective colleges, the executive branch including the Development Board, and the General Assembly. Such a group would serve a useful purpose as a coordinating and disseminating agency which could frame general programs on a policy level for consideration by the executive and legislative branches.

The Committee therefore recommends the creation of a continuing Committee to be called "State Organization for Associated Research" to be composed of the Presidents of the University of South Carolina and Clemson, one person appointed by the Governor, preferably the Director of the Development Board or a member of the Governor's staff concerned with industrial development, three members of the Senate appointed by the President and three members of the House of Representatives appointed by the Speaker.

The Committee devoted a considerable amount of thought and attention to the selection of a name for this agency. It was the belief of the Committee that the name should embody three principal requisites. In order of importance, it was felt that the name given this new and vital State organization should: 1. Express the purpose for which the agency was created; 2. express the great degree of cooperation required in such an undertaking; and 3. incorporate in its alphabetical abbreviation the long-range purpose for which the agency's work will be carried on.

With these considerations in mind, the Committee selected "State Organization for Associated Research", which embodies the character and purpose of the group and its aim of cooperation and mutual fulfilment. Abbreviated, the agency's letters spell "SOAR", which the Committee feels is the economic desire of not only the present ad-

ministration, but also of every thoughtful man and woman in South Carolina. Industrially and economically, our dedicated purpose is growth. Thus, the Committee believes that a SOARing South Carolina is the goal of the State and our people.

This group should make an annual recommendation to the Governor, Budget and Control Board and General Assembly as to the amount which should be appropriated annually for the state's research effort, and to what agencies the funds should be allotted. They should also submit an annual report showing the research activities and accomplishments for the year.

It is recommended that the 1960 General Assembly appropriate the sum of $500,000.00 to stimulate, enlarge and expand the research program of the state. It is further recommended that this lump sum appropriation be expended only upon the approval of the Budget and Control Board after receiving recommendations as to allocations from the Committee above recommended to be created.

This report does not include any recommendations with respect to state sponsored methods of providing additional capital for business expansion. The Committee has examined plans in use in other states, most of which plans involve a pledging of the State's money or credit, directly or indirectly to supply venture capital for new or expanding businesses.

Such financial schemes or methods are generally contrary to the business and governmental philosophy which we think is an attractive feature of our good business climate. Therefore the Committee does not have any recommendation to make at this time which will involve state participation in plans to provide additional industrial capital.

We commend the leaders of the newly organized Business Development Corporation on what we believe is a sound, progressive approach to this problem, a solution consistent with our business philosophy and free from the dangers inherent in too much government participation in private industry.

Respectfully submitted,

SENATE MEMBERS:
JOHN C. WEST, *Chairman,*
MARSHALL J. PARKER,
WILLIAM C. GOLDBERG.

HOUSE MEMBERS:
ROBERT E. MCNAIR, *Vice-Chairman,*
BARNEY DUSENBURY, *Secretary,*
REX L. CARTER.

EXHIBIT 1

PROPOSAL FOR THE EXPANSION AND STRENGTHENING OF THE BUREAU OF BUSINESS AND ECONOMIC RESEARCH

SCHOOL OF BUSINESS ADMINISTRATION
University of South Carolina

It is proposed:

I. That the Bureau of Business and Economic Research, established in 1953, be expanded and strengthened in personnel and facilities to meet the recommendation of the Joint Legislative Committee Surveying the Needs of the South Carolina State Development Board. The recommendation of the Committee was as follows:

"With respect to research in the economic field, the Committee notes with approval the work of the Bureau of Business and Economic Research at the University of South Carolina and feels that the expansion of the work of that agency and a closer identification of it with the State Development Board will be an adequate beginning answer to the need for research in this field."

(Journal of the Senate of South Carolina,
March 31, 1959, p. 29.)

II. That the Bureau shall continue to propose, initiate, conduct and publish studies dealing with business and economic problems. That studies of both a theoretical and practical application shall be undertaken. Such studies may be of state, national or international scope. However, for the present they will seek to find answers to important and basic questions such as these:

1. What is the impact of state and local taxes on industrial development?

2. What is the labor picture in South Carolina, and in what way does it influence plant location?

3. What are the opportunities for new and broader uses of South Carolina farm and forest products and raw materials?

4. What are the product opportunities in local and regional markets for existing and new industries?

5. How do transportation rates, facilities and services affect the competitive position of South Carolina manufacturers?

6. How adequate are existing and planned power and fuel supplies to meet future requirements?

III. That state and private agencies and individuals shall be consulted to determine those topics of statewide interest that are of immediate concern to the long-run welfare of the state. That the responsibility for the selection of topic for study shall rest with the Director of the Bureau with the advice and approval of the Committee on Research from the faculty of the School of Business Administration and the Department of Economics.

IV. That the Bureau shall endeavor to service requests for information from state agencies as well as from other responsible groups or individuals.

V. That professional staff of the Bureau shall participate in the teaching program of the University's School of Business Administration and Department of Economics and that they shall be given appropriate academic rank. The amount of time devoted to teaching may vary from semester to semester. It shall be determined by the Dean of the School of Business Administration and the Head of the Department of Economics.

VI. That staff and budget requirements as set forth on the attachment be used as a model for the Bureau.

PROPOSED BUDGET AND PERSONNEL REQUIREMENTS FOR THE EXPANSION AND STRENGTHENING OF THE BUREAU OF BUSINESS AND ECONOMIC RESEARCH

SCHOOL OF BUSINESS ADMINISTRATION
University of South Carolina

Fiscal Year 1959-60

Personnel:

Full-time:	
Director	$ 10,200.00
Industrial Economist	9,500.00
Marketing Specialist	9,500.00
3 Research Assistants @ $3,500.00 each	10,500.00
Editorial Assistant	3,300.00
Secretary (Stenog., Librarian, Files, Accts.)	3,600.00
	$ 46,600.00

Part-time:		
Population Analyst (4 months equivalent)	$ 3,600.00	
Economic Resources Analyst (4 months equivalent)	2,500.00	
Management Analyst (Editorial Services)	500.00	
		$ 6,600.00
Contingent Account for Personal Services:		
For special payments as need arises for graphics and layout, etc., and for salary adjustments that may be necessary	$ 5,000.00	
		$ 5,000.00
		$ 58,200.00
TELEPHONE		$ 350.00
OFFICE SUPPLIES		600.00
TRAVEL		2,000.00
OFFICE EQUIPMENT		1,250.00
POSTAGE AND MAILING		500.00
PRINTING		4,500.00
EDUCATIONAL SUPPLIES (Subscriptions, memberships, books under $10.00, periodicals)		700.00
EDUCATIONAL MATERIALS		400.00
REPAIRS TO EQUIPMENT		100.00
TOTAL		$ 68,600.00

EXHIBIT 2

RESEARCH IN SCIENCE AND ENGINEERING AT THE UNIVERSITY OF SOUTH CAROLINA

This report presents information about the present status of research and advanced teaching in the scientific and engineering departments of the University of South Carolina, and suggests the ways in which the University might best serve the future development of the state, particularly with regard to its industrial expansion.

Prior to World War II the University had little to offer along these lines. Since that time there has been rapid advance, as this report indicates. In order to utilize to the best advantage its scientific and technical potential, the University formed, in March 1958, its Institute of Science and Technology. This is discussed in detail later in the report.

The report concludes with some specific suggestions for the future.

Science and Engineering Departments:

The departments of the University that are of concern in this report are:

	Faculty		*Graduate Degrees Offered*	
	Total	*Ph.D.*	*M.S.*	*Ph.D.*
Department of Biology	9	7	x	x
Department of Chemistry	9	9	x	x
Department of Geology and Geography	8	5	x	
Department of Mathematics	20	15	x	
Department of Physics	9	6	x	x
Department of Chemical Engineering	3	3	x	
Department of Civil Engineering	9	1		
Department of Electrical Engineering	7	2	x	
Department of Mechanical Engineering	5	1		

Physical Facilities for Research:

The facts and figures that follow refer to the existing space and facilities. The University is in the preliminary stages of providing, through new construction, more space for all the departments listed.

	Total Usable Space and Per Cent Devoted to Research	*Special Equipment*
Biology	14,000 sq. ft.— 6½%	Phase Contrast Microscope; Walk-in Cold Room; Centrifuge; Scaler and Other Radiation Detection Equipment.
Chemistry	19,000 sq. ft.—25%	Infra-red and ultra-violet Recording Spectrophotometer, Vapor Chromatographs;

	Total Usable Space and Per Cent Devoted to Research	*Special Equipment*
		Rudolph Polorimeter, Radiation Detection Equipment; Vacuum Lines; Automatic Titration Equipment; Distillation Apparatus; Precision Apparatus for measuring Conductivity, Capacitance, etc.
Geology	12,500 sq. ft.	Microscopes; Sectioning Equipment; Compasses; Library.
Mathematics	12,000 sq. ft.	
Physics	14,000 sq. ft.— 8½%	No large items, fairly good stock of nuclear counting and detecting equipment.
Chemical Engineering	6,200 sq. ft.—13%	Oldershaw Plate Distilling Columns; Small Analog Computer, Thermal Conductivity and Heat Capacity Measuring Equipment; Scalers and Radiation Detection Equipment.
Civil Engineering	22,000 sq. ft.—23½%	Wave Tank; Recorders; Strain Gages; Universal Testing Machine.
Electrical Engineering	12,400 sq. ft.—22½%	Millimeter wave sources and apparatus; Vacuum laboratory including vacuum system, welders, microscope, sealing machine and glass lathe; High speed oscilloscopes, pulse generators, function generators, etc.
Mechanical Engineering	12,100 sq. ft.— 3%	Dual-Beam Oscilloscope; Lubrication Test Rig.

Research Personnel:

Two important functions of the University are (1) instruction and (2) the gaining of new knowledge, or research. When students are involved in the latter, as indeed they must be at the graduate level and may be as undergraduates, these two functions overlap and a faculty member does both simultaneously. Research, therefore, should not be viewed as something separate and special but as a normal activity.

	Distribution of Research Effort				
	Full-time	*More than ½*	*Approx. ½*	*Approx. ¼*	*Some*
Faculty	0	2	4	22	10

	Full-time	*Part-time*
Post-Doctoral Fellows	5	..
Ph.D. Students	5	7
M.S. Students	5	33
Undergraduate Students	..	26

Research In Progress:

Principal Investigator	*Title or Subject*	*Outside Support*
B. L. Baker (Chemical Engineering)	Radioactive Waste Disposal (Adsorption Studies)	U. S. Atomic Energy Commission
	Physical Properties of Heavy Water	U. S. Atomic Energy Commission
	Vapor-Liquid Equilibrium Studies of Binary and Ternary Systems	
	The Effect of Polarity upon the Activity Coefficients of Binary and Ternary Systems	
	Heat Transfer to a Condensing Surface in Presence of Inert Gases	
W. T. Batson (Biology)	The Accumulation of Radioactive Materials by Different Species of Native Plants	U. S. Atomic Energy Commission
O. D. Boner (Chemistry)	Ion Exchange Equilibria	U. S. Atomic Energy Commission
E. Breitenberger (Physics)	Theory of Random Processes	
D. O. Bushman (Geology and Geography)	Environmental Effects and Stresses on Military Operations	Waterways Experiment Station, U. S. Army
D. F. DeTar (Chemistry)	Mechanisms of Enzyme Reactions	National Institute of Health
	Free Radical Chemistry	Petroleum Research Fund of American Chemical Society
	Organic Reaction Mechanisms	National Science Foundation
	Reactions of Free Radicals with Aromatic Rings	Air Force, Office of Scientific Research
R. D. Edge (Physics)	Cosmic Ray Neutrons	National Science Foundation
R. G. Fellers (Electrical Engineering)	Non-Waveguide Methods of Millimeter Wave Transmission	Air Force, Office of Scientific Research
Harold Flinsch (Civil Engineering)	Effect of Wind on Waves	
	Effect of Waves on Beaches	
W. R. Ferris (Electrical Engineering)	Effect of Electrode Surface Conditions on Tube Performance	Air Force, Office of Scientific Research

Principal Investigator	*Title or Subject*	*Outside Support*
H. W. Freeman (Biology)	An Ecological Study of the Fishes of the Savannah River Drainage	U. S. Atomic Energy Commission
F. H. Giles (Physics)	Transients in Electrochemical Systems	
W. R. Gilkerson (Chemistry)	Properties of Non-Electrolytes in Non-Aqueous Solvents	U. S. Army, Office of Ordnance Research
	Rates of Dissociation of Ion Pairs	Research Corporation
G. R. Graham (Geology and Geography)	Census Tracts for City of Columbia	City of Columbia, S. C. Planning Board
W. R. Kelley (Biology)	An Ecological Study of the Vascular Shore Plants of the PAR Reservoir, Savannah River Plant	U. S. Atomic Energy Commission
J. L. Kice (Chemistry)	Mechanism of Disproportionation of Sulfinic Acids	Research Corporation Sloan Foundation
	Free Radicial Reactivity toward Non-Benzenoid Hydrocarbons	National Science Foundation
Roberta Lovelace (Biology)	Chromosome Breakage by *x*-rays	
E. C. Lerner (Physics)	Field Theory	
I. O. MacConochie (Mechanical Engineering)	Investigation of Oil Film Thicknesses	
J. F. McCauley (Geology and Geography)	Geology of Newberry County	South Carolina Development Board
J. H. Noland (Electrical Engineering)	Properties of Electrolytic Capacitors	General Electric Co.
J. D. Novak (Mathematics)	Generalization of Curvature of Curves and Surfaces	
J. T. Penney (Biology)	The Taxonomy and Distribution of the Spongillidae	
E. S. Perry (Geology and Geography)	Oil Fields of Montana	Montana Bureau of Mines and Geology
J. J. Petty (Geology and Geography)	Environmental Effects and Stresses on Military Operations	U. S. Army, Waterways Experiment Station
David Ridgeway (Geology and Geography)	Geology of Blaney Quadrangle	S. C. Development Board
W. H. Scheffey (Geology and Geography)	Geographic Aspects of Lutheran Settlement in South Carolina	

Principal Investigator	*Title or Subject*	*Outside Support*
L. L. Smith (Geology and Geography)	Kyanite in South Carolina	
Johann Sonner (Mathematics)	Duality Theorems in Algebraic Function Fields	
J. E. Sees (Electrical Engineering)	Properties of Electrolytic Capacitors	General Electric Co.
P. C. Teague (Chemistry)	Benzoin Condensations of Pivalaldehyde	U. S. Army, Office of Advance Research
Karl Wattkins (Mathematics)	Estimations of Series Development of Solutions of Differential Equations	
J. D. Waugh (Civil Engineering)	Cozzone Theory Applied to Reinforced Concrete	

Non-University Financial Support of Research in Science and Engineering:

The extent to which a research program can attract outside support is one measure of its quality. Only in recent years has the University of South Carolina enjoyed very much support of this type but there has been an encouraging increase. The record for the last five years follows:

	1954–55	1955–56	1956–57	1957–58	1958–59
Biology	$ 9,200	$ 7,200	$ 20,700	$ 24,200	$ 21,700
Chemistry	29,400	23,100	38,200	65,500	91,600
Geology	.....	.....	.....	.....	15,250
Mathematics	4,300	7,500	7,800	2,800	.....
Physics	10,000	10,200	21,400	2,500	.....
Chemical Engineering	.....	6,700	31,500	30,000	17,400
Electrical Engineering	.....	.....	8,934	27,100	18,900
Totals	$ 52,900	$ 54,700	$ 128,534	$ 152,100	$ 164,850

Graduate Degrees Granted, 1954-59:

Masters

	1954–55	1955–56	1956–57	1957–58	1958–59
Biology	1	1	3	1	2 + 2
Chemistry	4	2	4	4	3
Geology and Geography	.	.	1	2	1
Mathematics	.	1	3	1	2
Physics	1	1	1	5	1
Chemical Engineering	.	.	.	.	.
Electrical Engineering	.	.	.	.	2

Doctor of Philosophy

Chemistry	.	3	1	1	2
Biology	1	.	1	.	1

General Research Facilities:

a. Library: The science and engineering departments have been able in recent years to acquire a rather good collection of journals and reference books. However, they are not nearly as accessible and convenient for use as is necessary for full utilization of our research potential.

b. Machinist and Shop Service: Research in science and engineering as it must be carried out these days requires a great deal of equipment, often made especially and not available commercially. This makes necessary the services of machinists and instrument makers. We have neither the tools nor the equipment necessary for this type of research assistance.

c. Computational Service: This need has been met by the very recent acquisition of a Royal-McBee LGP-30 Digital Computer, which should be adequate for our needs for some time.

The University of South Carolina Institute of Science and Technology:

The Institute was formed in the Spring of 1958 after some months of study and planning. The following are excerpts from the original statement of its intention and functions:

"The Institute will be an administrative instrument of the University for the enhancement of services rendered to the State by the already established science and technical departments. More specifically, the purposes of the Institute will be to encourage fundamental research in pure and applied science and to improve teaching programs in the sciences at the University; to assist the development of science; teaching in the public schools of South Carolina; and to render appropriate services to industry and to the public of the State.

"While it is essential that all pertinent available knowledge be utilized and passed on through education to coming generations, that is only part of the task confronting our nation's universities. The University of South Carolina also shares the task of providing an adequate program of basic research so that our scientific and our technological advance will continue. Our scientists of today must be guaranteed the maximum support for their basic research so that the applied scientists of tomorrow may continue the advances which have made our nation second to none.

"Although the basic research output of governmental and industrial laboratories is now increasing, a major part of this fundamental research is carried on in college and university laboratories. We believe that this will and should continue to be the case. There is no substitute for the academic atmosphere of constant questioning and free inquiry for the development of basic research.

"It is obvious, therefore, that our science and engineering faculties at the University of South Carolina must be kept strong, indeed further strengthened, and that they must be provided with the necessary facilities and incentives for research. These facilities, it may be noted, grow more complicated and require more intense planning as knowledge increases. A function of the Institute will be to provide leadership, planning guidance, and inspiration and, thus, to further the intellectual spirit of inquiry among members of the faculty.

"Another factor which enters into any consideration of the University of South Carolina's tasks is the rapid industrial development in this State. This provides another important reason for the establishment of an Institute of Science and Technology. We realize that progress in education and research on one hand and improvement of the State's economy and the livelihood of its people on the other are mutually dependent. It is thus obvious that both initiative and concerted effort are required if we are going to provide the research to develop resources."

The Institute is essentially the combined forces of the science and engineering departments. It has not involved the setting up of any special administrative positions or of its own physical facilities. Its purpose is to strengthen the scientific research and training programs through co-operative procedures. A specific instance of this is the recent acquisition (in June 1959) of a digital computer.

Since interest has been shown in the experience of Arkansas with its Graduate Institute of Technology (G.I.T.) at Little Rock it is worth pointing out that the equivalents of nearly all the operations of G.I.T.—and much more besides—are already provided in South Carolina by the University.

Relationship of University Research Program to the Development of the State:

1. The greatest contribution that the science and engineering departments of the University can make toward the future development of the state will be the expansion of their existing programs of advanced teaching and research.

"It was precisely the existence of a flourishing research community in Durham, Raleigh, and Chapel Hill that made possible the 'Research Triangle' project in North Carolina. The notion that the academic institutions might undertake applied research to any great extent was not a consideration in the establishment of the Research Triangle; the real attraction was the fundamental research atmosphere, the communities of recognized scholars, and the presence of such facilities as departmental libraries that cannot be created at will."

2. There are also many specific advantages that will come from a strong research and advanced teaching program at the University:

(a) It will be an increasing source of graduates at all levels of scientific training up through the Ph.D.;

(b) It can provide further training of industrial research personnel in existing degree programs, or in special courses for which there is demand;

(c) Its individual faculty members will be potentially available as consultants, and some of them may work at times in nearby research laboratories in a mutually beneficial arrangement:

(d) Seminar and visiting lecturer activities could be expanded to provide technical discussions that would be profitable to nearby research workers;

(e) Research services of the University such as library, etc., could be used by industrial research people to advantage. Indeed, the library is already used on numerous occasions by such people.

Some expansion of faculty and facilities would be necessary to enable the University to provide these services most effectively.

3. The University may on occasion, when it is mutually beneficial, undertake contract research for industry.

"This research should be related to basic principles and should not be of a day-to-day problem solving nature. Also such research should not divert faculty members from basic and fundamental research that they would otherwise be doing. Proposals for research of this nature would be presented to the Executive Committee of the Institute for evaluation. Such proposals would be approved if they were found to be consonant with the best interest of the University."

Let it be repeated and emphasized that the role of the University as an attraction to industry can best be carried out by permitting it to become good enough so that its reputation will be extended beyond the borders of this State.

APPENDIX

Constitution of the Institute of Science and Technology

By the terms of its original statement of policy and function, the Institute is organized as follows:

(a) All faculty members of physical science and engineering departments who are interested in research are members of the Institute staff.

(b) The Institute has a Director who will serve at the pleasure of the President of the University.

(c) The Institute operates under the supervision of an Executive Committee consisting of the Director and four other members appointed from the faculty by the President. The appointed members serve for two years (except that two of the initial appointments in 1958 were for one year only).

(d) The Institute has an Advisory Council consisting of people not connected with the University who, by their accomplishments, have demonstrated their fitness for such appointment. Appointments shall be made by the President of the University for terms of designated duration. The Director shall serve as Secretary of the Council.

(e) All funds shall be received and disbursed through the normal channels of the University.

The present memberships (June 1959) of the Advisory Council and of the Executive Committee are listed on the following page.

Advisory Council

Mr. T. C. Bannister, Plant Manager, Bowaters Carolina Corporation, Catawba, South Carolina.

Dr. B. M. Edwards, South Carolina National Bank, Columbia, South Carolina.

Mr. Francis M. Hipp, President, Liberty Life Insurance Company, Greenville, South Carolina.

Mr. Leland Jones, Plant Manager, E. I. duPont deNemours & Co., Inc., Camden, South Carolina.

Mr. John H. Martin, Sr., Vice-President, Sonoco Products Company, Hartsville, South Carolina.

Dr. Ellison McKissick, Treasurer, Alice Manufacturing Company, Easley, South Carolina.

Mr. A. E. Peltosalo, General Manager, General Electric Company, Irmo, South Carolina.

Mr. W. J. Ready, Vice-President & Comptroller, S. C. Electric & Gas Company, Columbia, South Carolina.

Mr. E. H. Seim, Plant Manager, Micarta Division, Westinghouse Electric Corporation, Hampton, South Carolina.

Mr. Robert H. Sloan, Plant Manager, Albany Felt Company, St. Stephen, South Carolina.

Dr. Milton Wahl, Director, Savannah River Laboratory, E. I. du-Pont deNemours & Co., Inc., Aiken, South Carolina.

Mr. W. F. Whitescarver,* Coffin's Point Plantation, Frogmore, South Carolina.

EXECUTIVE COMMITTEE

Dr. W. T. Batson ** ..... Acting Head, Dept. of Biology
Dr. H. W. Davis (Director) ..... Head, Dept. of Chemistry
Dr. R. G. Fellers ..... Head, Dept. of Electrical Engineering
Dr. A. P. French ..... Head, Dept. of Physics
Dr. W. L. Williams ** ..... Head, Dept. of Mathematics

EXISTING RESEARCH FACILITIES AT THE UNIVERSITY OF SOUTH CAROLINA

The single most important factor in the development and execution of a research program is a strong graduate school operating at both the Master's degree level and the Ph.D. level. As of the 1958-59 academic year the University of South Carolina was the only institution in the state offering the Ph.D. degree in science.

At the present time Master's degree programs are offered in Biology, Chemistry, Geology, Mathematics, Physics, Chemical Engineering, and Electrical Engineering. Recent staff additions in Mechanical Engineering will permit Master's degree work in that area in the immediate future.

The Ph.D. degree is a necessary qualification for a research career in science and the offering of such a degree goes hand in hand with the development of a truly outstanding research program. At the present time the University offers the Ph.D. degree in Biology, Chemistry, and Physics, and will offer it in Mathematics with the beginning of the fall 1960 term. Support for the doctoral programs in Physics and Mathematics have been obtained in part from National Defense Education Fellowships. The number of advanced de-

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* Former Manager, Paint and Varnish Division American Cyanamide Company, New York, N. Y.

** One-year appointments, now expiring.

grees in science awarded annually has more than doubled in the past five years.

One of the most significant contributions that research and graduate study can make to the economy of the state is the provision of a supply of well trained research scientists and engineers for the laboratories of industry.

Science Departments

Biology:

The Biology Department has a staff of nine including seven Ph.D.'s. Special research equipment available includes the following items:

Phase Contrast Microscope; Walk-in Cold Room; Centrifuge; Scaler and other Radiation Detection Equipment.

Research projects currently in progress are listed below:

Project	*Support*
The Accumulation of Radioactive Materials by Different Species of Natige Plants	U. S. Atomic Energy Commission
An Ecological Study of the Fishes of the Savannah River Drainage	U. S. Atomic Energy Commission
An Ecological Study of the Vascular Shore Plants of the PAR Reservoir, Savannah River Plant	U. S. Atomic Energy Commission
Chromosome Breakage by X-Rays	
The Taxonomy and Distribution of the Spongillidae	

Of the projects listed above those sponsored by the Atomic Energy Commission are in support of the activities of the Savannah River Plant of the Atomic Energy Commission.

Chemistry

The Department of Chemistry has a staff of nine, all holding the Ph.D. degree. This Department is very active in research and has been described by qualified outside observers as the equal of any its size in the United States.

Special Research equipment includes the following items:

Infra-red and ultra-violet Recording Spectrophotometer, Vapor Chromatographs; Rudolph Polarimeter, Radiation Detection Equipment; Vacuum Lines; Automatic Titration Equipment; Distillation Apparatus; Precision Apparatus for Measuring Conductivity, Capacitance, etc.

Research projects currently in progress are listed below:

Project:	*Support:*
Ion Exchange Equilibria	U. S. Atomic Energy Commission
Mechanisms of Enzyme Reactions	National Institute of Health
Free Radical Chemistry	Petroleum Research Fund of American Chemical Society
Organic Reaction Mechanisms	National Science Foundation
Reactions of Free Radicals with Aromatic Rings	Air Force, Office of Scientific Research
Properties of non-Electrolytes in non-Aqueous Solvents	U. S. Army, Office of Ordnance Research
Rates of Dissociation of Ion Pairs	Research Corporation
Mechanism of Disproportionation of Sulfinic Acids	Research Corporation Sloan Foundation
Free Radical Reactivity toward non-Benzenoid Hydrocarbons	National Science Foundation
Benzoin Condensations of Pivaldehyde	U. S. Army, Office of Advance Research

Much of this research is basic in nature with the intent of extending the frontiers of knowledge. It is on such basic research that all applied research must depend. It is apparent from the names of the sponsors that this work is of importance to both government and industry.

Department of Geology and Geography

The Department of Geology and Geography has a staff of seven including five Ph.D.'s. Special research equipment includes:

Microscopes; Sectioning Equipment; Compasses; Library.

Research projects currently in progress are listed below:

Project:	*Support:*
Environmental Effects and Stresses on Military Operations	Waterways Experiment Station, U. S. Army
Census Tracts for City of Columbia	City of Columbia, S. C. Planning Board
Geology of Newberry County	South Carolina Development Board
Oil Fields of Montana	Montana Bureau of Mines and Geology
Environmental Effects and Stresses on Military Operations	U. S. Army, Waterways Experiment Station
Geology of Blaney Quadrangle	S. C. Development Board
Geographic Aspects of Lutheran Settlement in South Carolina	
Kyanite in South Carolina	

This Department has been working in close cooperation with the State Development board as indicated below.

The Development Board has from its inception, called upon members of our department for consultation and for the support of its various projects. Two of our geologists made contributions to several of the Board's early publications and one large bulletin was entirely authored by a geographer in our department. With the recent creation of a Division of Geology by the Development Board our cooperative efforts have been greatly multiplied. Many of our interests are common ones and our facilities and resources for their solution are mutually complimentary.

The Department of Geology being, as it is, one of the two oldest in the country understandingly possesses an excellent reference library and has built up an unusually extensive collection of mineral specimens and fossils. The library is indispensable to the Division of Geology (Development Board) for the furtherance of essential research and

in the compilation of data to be used in encouraging industry to exploit our mineral resources. Their geologists have access to our library and use it freely; their manuscript writer and editor of special articles find it a necessity; and numerous visitors interested in gathering information regarding the geology and resources of the state find our library and our collections to be of essential assistance.

The Division of Geology is confronted with the necessity of employing additional personnel for the pursuit of basic geologic studies and, accordingly, it has for the past several years employed a member of our staff during his free summer months. Dr. J. F. McCauley was engaged during the recent summer in making a study of the Geology of Newberry County. So far, two of our graduate students have, for their Master's theses, selected field problems in which the Division of Geology was mutually interested and students majoring in our department have been employed as field and as laboratory assistants.

During the past two years a member of our staff has acted as advisor and consultant to parties whom the Division of Geology has been encouraging to invest in the development of our mineral deposits. Through this service the prospective investor has received technical assistance at little, and in many cases no expense to himself or to the company whom he represents.

The University furnishes the Division of Geology with the free use of a large room on the ground floor of Coker College. This space if utilized for storage and for the maintenance of a Mineral Industries Laboratory.

On the opposite side of the ledger, our Department of Geology and Geography receives desired benefits from its association with the Division of Geology. Of great importance is the opportunity afforded to members of our department for summer employment and for expenses inherent in their research work. This situation could be a strong inducement in attracting outstanding young men to our teaching staff.

The Division of Geology has contributed toward the expenses of our graduate students in their work on field problems assigned to them as subjects for Master's theses.

As the prestige of the Division of Geology grows and as its value to the state becomes generally recognized, it is to be hoped that increased inducements will be offered to both the members of our staff and to the graduate students in our department. There are areas in which our geographers as well as our geologists could make notable contributions toward the state's problems.

In addition to the space furnished gratis to the Division of Geology, the University provides the Ground Water Branch of the U. S. Geological Survey with the use of several rooms in our Freshmen Center where this organization maintains an established office and laboratory. The Ground Water Branch is also given free access to our library of which it makes entensive use. An arrangement exists between the State Development Board and the U. S. Geological Survey whereby a water resources program is supported on an equal financial basis.

The University and its Department of Geology and Geography are fostering a close liaison between their interests and those of geological divisions of the state and federal governments. Today's geological problems are increasingly demanding the combined efforts and techniques of numerous students of the science and it is desirable that the cooperation efforts of such workers be encouraged.

Mathematics

The Department of Mathematics has a staff of twenty including fifteen Ph.D.'s. This Department will offer the Ph.D. degree beginning in the Fall of 1960, and has received a fellowship grant for that purpose under the National Defense Education Act.

Research projects currently in progress are listed below:

Project:	*Support:*
Generalization of Curvature of Curves and Surface	
Duality Theorems in Algebraic Function Fields	
Estimations of Series Development of Solutions of Differential Equations	

Much of this research is of a basic nature as is usually the case in Mathematics. With the commencement of the Ph.D. program it is expected that there will be considerably increased research activity in this Department. A strong Mathematics Department is the most important underpinning of all physical science and engineering.

Physics

The Department of Physics has a staff of nine including six Ph.D.'s. Special research equipment includes:

Nuclear counting and detecting equipment, High speed Oscilloscopes, Wide-band amplifiers, microscopes, Cosmic ray apparatus.

Research projects currently in progress are listed below:

Project:	*Support:*
Theory of Random Processes	
Cosmic Ray Neutrons	National Science Foundation
Transients in Electrochemical Systems	
Field Theory	

In recent years this Department has added to its staff several physicists with outstanding records of research and Doctor's degrees from the great universities of the world, Cambridge, Vienna, Illinois, MIT for example. The potential for increased research activity in this Department is great.

Archaelogy:

Archaeological research is carried on at the University in the Department of Anthropology and Sociology. It has been possible to commence research in this important field with the addition to the staff of a qualified archaeologist, Dr. William E. Edwards. Since the fall of 1959 an impressive start has been made in archaeological research by Dr. Edwards assisted by numerous students. A large number of field trips have been conducted and much valuable data has been collected.

South Carolina is a region of great archaeological interest and an area in which almost no research has been done. In order to attempt to fill this glaring gap it is essential that expanded research work be undertaken immediately before any more important sites are destroyed by construction and by casual diggers.

Engineering Departments

Chemical Engineering:

The Department of Chemical Engineering has three staff members including two Ph.D.'s. Special research equipment includes:

Older Shaw Plate Distilling Columns; Small Analog Computer, Thermal Conductivity and Heat Capacity Measuring Equipment; Scalars and Radiation Detection Equipment.

Research projects currently in progress are listed below:

Project:	*Support:*
Radioactive Waste Disposal (Adsorption Studies)	U. S. Atomic Energy Commission
Physical Properties of Heavy Water	U. S. Atomic Energy Commission
Vapor-Liquid Equilibrium Studies of Binary and Ternary Systems	
The Effect of Polarity upon the Activity Coefficients of Binary and Tenary Systems	
Heat Transfer to a Condensing Surface in Presence of Inert Gases	

Some of these studies are of direct interest and benefit to the Savannah River Project to the Atomic Energy Commission. Present plans call for this Department to move into a new building, (construction of which is expected to begin in 1960).

Civil Engineering:

The Department of Civil Engineering has nine staff members including one Ph.D. Research equipment includes:

Wave tank, Recorders; Strain Gages; Universal Testing Machine.

Research projects currently in progress are listed below:

Project:	*Support:*
Effect of Wind on Waves	
Effect of Waves on Beaches	
Cozzone Theory Applied to Reinforced Concrete	

These projects are both of possible commercial interest in the fields of navigation and construction.

Electrical Engineering:

The Department of Electrical Engineering has eight staff members including three Ph.D.'s. Research equipment includes:

Millimeter wave sources and apparatus; Vacuum Laboratory including vacuum system, welders, microscope, sealing machine

and glass lathe; High speed oscilloscopes, pulse generators, function generators, etc.

Research projects currently in progress are listed below:

Project:	*Support:*
Non-Waveguide Methods of Millimeter Wave Transmission	Air Force, Office of Scientific Research
Effects of Electrode Surface Conditions on Tube Performance	Air Force, Office of Scientific Research
Properties of Electrolytic Capacitors	General Electric Co.

The projects sponsored by the Air Force are of long time benefit to the defense effort. The third project has been of direct benefit to industry.

Mechanical Engineering:

The Department of Mechanical Engineering has six staff members including one Ph.D. Two additional individuals holding the Doctor's degree have already accepted positions to join the staff in February and September, 1960. Research equipment includes:

Dual beam oscilloscope, Calculators, Instruments, Lubrication test rigs, Metallurgical Laboratory equipment.

New research laboratory space of about 900 sq. ft. is presently being completed. It is expected that this Department will occupy part of a new building on which construction is to commence in 1960.

Research projects currently in progress are listed below.

Project:	*Support:*
Characteristics of Stable Flames in High Velocity Gas Streams	
An Investigation of Oil Film Thickness Between Involute Gear Teeth	Office of Ordnance Research

The first of these projects is applicable to missle propulsion studies and the second has commercial as well as military applications.

With additional space and the newly acquired staff members this department has the potential for greatly increased research activity.

Digital Computer Facility

In the summer of 1958 the University acquired a Royal McBee LGP-30 digital computer and established a computer laboratory in the Engineering Building for use in connection with Electrical Engineering courses and for research application of the University as a whole. This machine has been used on research projects in electrical engineering, chemical engineering, and political science. It is applicable to use in almost all fields of research both scientific and non-scientific and negotiations have been undertaken to apply the computer to the problems of some local industries. This computer facility is being financed in part by a grant from the National Science Foundation.

Exhibit 3

SUGGESTED EXPANDED RESEARCH PROGRAM, USC

1. That there should be formed an academic research liaison committee comprised of one representative from the University of South Carolina, one from Clemson College, and Mr. Ernest Wright, Industrial Secretary to the Governor. This committee could meet several times during the year, its function being to supply information concerning the research activities and personnel of the two institutions. Inquiries for information about specific research activities at each institution could be channeled through the committee member representing it.

2. That a specific fund be provided annually for expanding and improving research in those departments comprising the University of South Carolina Institute of Science and Technology. A proposed budget for the first year is outlined below:

Research Faculty Salaries	$120,000.00
Twenty Graduate Research Assistantships	40,000.00
Fifty Undergraduate Research Assistantships	40,000.00
Research Equipment	50,000.00
Research Seminars, Visiting Lecturers, Etc.	5,000.00
Total	$255,000.00

The figure for Research Faculty Salaries would be used for additional highly qualified persons whose primary duty would be research and graduate instruction. It would not be used for increasing salaries of existing positions.

The provision of some undergraduate research assistantships would represent one of the most effective possible means of attracting out-

standing students into a scientific career at a stage when they are often lost to the state.

The addition of a qualified archaeologist to the University faculty has resulted in the commencement of research activity in that important science. In order to provide some financial support for this research an additional fund of approximately six thousand dollars is recommended as follows:

Research Staff Salaries	$ 3,000.00
Student Research Assistants	2,000.00
Supplies and Equipment	1,000.00
Subtotal	$ 6,000.00

The proposal for the expansion of the activities of the Bureau of Business and Economic Research was commented on favorably by the Governor in his address on January 12, 1960, to the General Assembly as follows:

"To keep pace with our economic and industrial expansion, the research programs of the University of South Carolina and Clemson should be expanded. An economic research center should be instituted at the University, as provided in the Budget Report. It is intended that this activity be carried on jointly with the State Development Board. This will furnish established industry expert economic studies and data needed for expansion or development plans. This is an extremely important facet of industrial development. However, another important feature is that it will furnish the basis for a top-flight business school at the University. The need for business executives, personnel managers, plant superintendents, is growing every day. While we have excellent schools in architecture, forestry, textiles, chemistry, engineering, and other fields, little emphasis has been placed on a superior business school. We should have this at the University."

The sum of $68,600.00 was included in the University request to the Budget and Control Board. Since the increase in the University budget recommended to the legislature by the Budget and Control Board was reduced to less than one-third of the requested increase it is considered necesary to include the sum of $68,600.00 in the recommendation for the support of increased research activity at the University.

The recommended budget is summarized below, including the new recommendation.

Original Recommendation	$255,000.00
Archaeological Research	6,000.00
Bureau of Busines and Economic Research	68,600.00
Total	$329,600.00

EXHIBIT 4

RESEARCH PROJECTS AT CLEMSON WITH COMMENTS

October 1, 1959

SCHOOL OF ARTS AND SCIENCES (PHYSICAL SCIENCE)

I

RESEARCH CURRENTLY UNDERWAY

A. *Department of Chemistry and Geology.*

(1) *Viscosity Variations in a Series of Alcohols.**

(2) *Sorption of Vapors by Polymeric Membranes.*

A non-sponsored study of interest to and possible economic advantage to the textile and paint industries.

(3) *Studies on EDTA Indicators.**

(4) *Analysis of Cations by Chloranilic Acid.**

(5) *A Study of the Hofmann Reaction with Substituted Phthalamides.**

(6) *The Synthesis of Nitrogen Mustard Derivatives of Phenanthridine.**

(7) *A Study of Stereoisomerism in Dibenzalacetone and Some of its Derivatives.**

(8) *The Synthesis of Some Substituted Pyrrolo-3, 4-d-pyrimidines.**

(9) *A Study of the Diels-Alder Reaction with Some Substituted Quinones.**

(10) *Molecular Weight Determinations on Lignins using the Signer Method.**

(11) *The Synthesis of Some Purine Analogs of Interest as Potential Anticancer Agents.*

A project sponsored by a grant of $7,474.00 from the National Institute of Health.

* These are basic research studies. No immediate known economic potential has been determined.

(12) *A Mineral Survey of Pickens County.*

A project sponsored by a grant from the State Development Board. Possible economic advantage to ceramic and allied industries.

(13) *An Investigation of the Sedimentery Cristobalite of the S. C. Coastal Plain.*

Sponsorship has been requested from the National Science Foundation. The project would be of interest to ceramic and allied industries.

(14) *The Determination of Copper and Zinc in Commercial Fertilizers by Complexometric Methods.*

This project is of interest to the Association of Official Agricultural Chemists.

B. *Department of Physics.*

(1) *A Study of Debye Characteristic Temperatures of Solids by X-Ray Diffraction.**

This project is sponsored by an $11,500.00 grant from the National Science Foundation.

(2) *Strain Measurements by the use of the X-Ray Diffractometer.**

(3) *Electrical Resistance of Cotton Fibers.*

This project has possible economic interest to the Textile industry.

(4) *Wave Length Distribution of the Silicon line of Hyperpure Silicon.**

(5) *A Study of Tubular Natural Uranium Fuel Elements.*

This project, in the National interest, is sponsored on a cost basis by the AEC Savannah River Laboratory.

II

Areas of Probable Future Research

(1) *A continuation and expansion of geological surveys.*

(2) *Applied projects of interest to the paint, fertilizer, and pulp-paper industries.*

(3) *A continuation and expansion of purely basic studies in Chemistry and Physics.*

(4) *A continuation and expansion of National interest projects, sponsored by federal agencies.*

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* These are basic research studies. No immediate known economic potential has been determined.

(5) *Chemical, mathematical, and physics determinations made in support of projects being undertaken in other schools of the college.*

School of Engineering

I

Research Currently Underway

A. *Department of Ceramic Engineering.*

(1) *Development of new uses for S. C. kyanite.**

(2) *A fundamental investigation of Clay Properties.**

(3) *Development of materials and a new method for making quarry tile.**

(4) *Development of S. C. materials for wall tile manufacture.**

(5) *Investigation of feasibility of producing light weight concrete aggregates from granite screenings.**

(6) *Development of new techniques for spectrographic analysis of ceramic materials.**

B. *Department of Chemical Engineering.*

The design and evaluation of the characteristics of a non-mechanical pulser to replace mechanical pulsers in radio-chemical processing.

This project is supported by a continuing grant from the Oak Ridge National Laboratory. To date $20,000.00 and considerable equipment has been made available by Oak Ridge. The project is in the National interest.

C. *Department of Civil Engineering.*

(1) *Investigation of local (S. C.) aggregates for concrete mixture.*

This continuing project is of economic interest to South Carolina construction industries.

(2) *Development of the lagooning method of sewage disposal.*

This project has economic utility for towns and villages throughout the state.

(3) *Studies of the Bearing Capacity of Soils.*

These studies are vital to the construction industry.

(4) *Different techniques in aerial photography for mapping purposes.*

This is a program which has obvious value to the State Development Board.

* Each of the six current projects being studied by the Ceramic Engineering Department is of interest to the ceramics industry and may be of direct value in attracting ceramic product manufacturers to the state.

(5) *Use of Fly Ash as a Partial Replacement for Cement in Concrete.*

A sponsored project with obvious industrial application.

D. *Department of Electrical Engineering.*

(1) *A method of controlling temperatures in a ceramic kiln.*

This is a companion study to those being conducted by the Ceramic Engineering Department and is of interest to ceramic manufacturers.

(2) *An Experimental Investigation of a transformerless d-c transistorized audio-power-amplifier output stage.*†

(3) *A method of visual Demonstration of FM.*†

(4) *A Direct-current analyzer for small water distribution systems.*†

E. *Department of Engineering Mechanics.*

This department at present has underway research dealing with the use of Photostress equipment in the quantitative analysis of stress distribution in the inelastic range. This is a basic study.

F. *Department of Mechanical Engineering.*

Currently this department is conducting an investigation of a device for use in determining the percentage of a gas which exists in the dissociated state within a volume of gas. This project has direct application to the field of ultra-high-speed missiles and is in the national interest.

II

Areas of Probable Future Research

(1) *Pilot line studies for setting up manufacturing operations in a variety of industrial plants.*

(2) *Detailed investigations of the physical properties of engineering materials and their behavior under load conditions.*

(3) *Investigations of fluid flow in open and closed conduits.*

(4) *Electrical instrumentation.*

(5) *Waste disposal problems.*

(6) *Spectrum analyses.*

(7) *The bearing capacity of soils.*

(8) *The use of local aggregates in construction.*

(9) *Product development, especially in ceramics.*

(10) *Problems of heat transfer and gas pressures.*

† Basic studies for which no immediate known economic potential has been determined.

(11) *Problems in machine design.*
(12) *Consultant work in industry.*

School of Textiles

I

Research Currently Underway

(1) Seven sponsored projects are underway. These are, with three exceptions, being conducted under contracts which prevent title listing. Sponsors are the American Enka Corporation, the duPont Company, United Merchants and Manufacturers, and Saco Lowell. Three projects being sponsored by the United States Department of Agriculture are (a) *Experimental Warping and Slashing;* (b) *Treatment of Cotton Fibers with Resins and Rubber;* and (c) *Improvement of Elastic Cotton Yarns.*
(2) *Evaluation of Textile Finishes Under Varying Temperatures and Humidities.*
(3) *Development of New Dyeing Techniques for Certain Synthetic Fibers.*
(4) *Improvement in the Bleaching Process for Cotton.*
(5) *A Study to Standardize Tests to Identify Mineral Stains on Cotton Fabrics During Wet Processing Caused by Water Impurities.*
(6) *A Study of the Variables in Mercerization of Cotton.*
(7) *A Study to Develop Means of Measuring the Percentage of Short Fibers in Gin Damaged Cotton.*

II

Areas of Probable Future Research

(1) *Instrumentation for Testing and Evaluating Textile Products.*
(2) *Instrumentation Study to Improve Textile Processing.*
(3) *Automation Studies on Textile Processing Machines.*
(4) *Textile Product Development.*
(5) *Textile Process Improvement and Machine Evaluation.*
(6) *Development of Methods for Combing Short Staple Cotton.*
(7) *Study of Fiber Blends to Determine Optimum Combinations.*
(8) *A Study of Drafting for Improved Yarn Quality and Increased Efficiency.*
(9) *A Study of Slashing to Seek Compounds that are Less Prone to Stream Pollution.*

(10) *A Study to Determine Treatments for Textile Waste to Reduce Stream Pollution.*

(11) *An Investigation to Develop Rapid Means for Fiber Identification in Textile Fabrics and Products.*

(12) *A Study of Wet Processing of Textiles with Varied Forms of Energy.*

(13) *Studies Leading to Improved Personnel and Management Practices in the Textile Industry.*

School of Agriculture

I

Research Currently Underway

(Note: The Experiment Station of the School of Agriculture is conducting 271 active projects, supported from state funds, federal funds, grants from industry, and revenue from the sale of farm products. No attempt will be made to list individual projects as such.)

(1) *Research in Beef Cattle, Swine, and Sheep.*

In 1958 the gross income from hogs and pigs, cattle and calves, and sheep and lambs was $30,607,000.00, $24,733,000.00, and $75,000.00, respectively.

Problem Areas Being Investigated:

(a) *Methods of Producing Slaughter and Feeder Cattle and Sheep.*

Research is underway to determine the best methods in producing the cattle on grassland or grass supplemented with a minimum amount of dry lot feeding. Studies are also underway to determine factors influencing rate of gain, carcass quality, and the factors affecting the color of fat. Increased slaughter of South Carolina produced livestock and increased sales of feeders have resulted from these investigations.

(b) *Systems of Fattening Swine.*

Research is being directed toward the production of better pig crops and the production of a better meat-type hog.

(c) *Internal Parasites in Cattle.*

Internal parasites cause heavy losses in cattle, sheep, and swine in certain seasons in local areas in South Carolina. Studies are underway to determine the conditions under

which these losses are most severe. Control methods and improved management methods are being developed to reduce losses from this problem.

(d) *Production of Early High Quality Lambs.*

The market for high quality lambs is excellent during the months of March, April, and May. The production of lambs which can be marketed in these months involves breeding during periods of high temperature. Since the conception rate under these conditions is very low, studies are underway to determine the causes of the low conception. Different breeds of sheep are being tested in the Coastal Plains to determine their adaptability to South Carolina conditions. The Ploworth has been introduced from Australia and ewes from different mid-western states have been imported into the state and bred to various types of rams to determine the adaptability of their off-spring for wool and meat production. Large scale studies are underway at the Johnsonville Station and it is felt that valuable information will be available from this source in the very near future.

(2) *Dairy Animals and Dairy Products.*

The annual gross income in South Carolina from dairy products is approximated at $44,200,000.00 annually. The sources are as follows: milk—$35,000,000.00; ice cream—$9,000,000.00; butter—$110,000.00; cottage cheese— $90,-000.00.

Problem Areas Being Investigated:

The Breeding, Management, and Feeding of Dairy Cattle.

The quantity of milk and its butter fat content produced by the dairy animals in South Carolina is still below that of many states. Research projects are in progress involving factors affecting feed and roughage utilization, factors affecting quality of milk and milk products, and pelleted forages.

(3) *Economics, Farm Management, and Farm Adjustments.*

Agriculture provides a large proportion of the raw materials, much of the labor, and a substantial part of the market for the other industries which make up our total economy. Furthermore, the open country has become strategic to the special requirements not only of manufacturing and transportation but even of the population itself. A survey in the

Piedmont area revealed that less than 40% of the rural people lived on farms in 1958. The South Carolina Agricultural Experiment Station was a pioneer in the study of such problems as "Industrial Development in Rural Areas," "Agricultural Labor Supply and Demand" and "The Labor Supply of Rural Industries." Officials of one firm stated publicly that a study by the South Carolina station, showing a "surplus" of about 11,000 rural farm workers in a small area, was the "turning point" in their choice of this area for a plant employing 6,000 workers.

Problem Areas Being Investigated:

(a) *The Economics of Harvesting, Handling, Processing and Marketing Crops and Livestock.*

Surveys are being made continuously to determine the methods employed in producing, harvesting, processing, and marketing of crops and livestock.

(b) *Projects are underway to compile data related to agriculturally based industries and their operational needs.*

(c) *Marketing Problems of Varied Nature are Being Investigated.*

(4) *Farm Mechanization.*

Despite the tremendous strides made in mechanization within the past decade, less than 2% of South Carolina's cotton crop is harvested with machines. The development of a machine adaptable to South Carolina conditions would reduce cost of harvesting by at least $20.00 per acre resulting in a saving of over $1,200,000.00 annually. The mechanization of tobacco is in its infancy. The rapidly increasing animal and dairy industries of South Carolina are using hand labor for most feeding operations. Cost of labor and machinery in producing corn was reduced from $36.95 per acre to $19.29 per acre for approximately 100-bushel corn yields by mechanization research at Clemson.

Problem Areas Being Investigated:

Cotton mechanization, handling, storage, and ginning; minimum tillage, harvesting of small seeds and grain, sub-soiling for field and vegetable crops, dehydrating and pelleting of southern forages, and causes of non-fluffed cotton.

(5) *Field Crops.*

In South Carolina at present, the major farm income is being secured from the sale of tobacco, cotton, and the cereal

crops. The annual income from these crops alone totals in excess of $200,000,000.00.

Problem Areas Being Investigated:

(a) *More Satisfactory Methods of Harvesting, Handling, and Curing Tobacco.*

Research is direct toward the lowering of the cost of production and increasing the quality of the product produced.

(b) *Improvement by Breeding of Cotton, Tobacco, and Other Field Crops.*

Fundamental genetic studies are underway with tobacco and cotton.

(c) *Variety Evaluation in Testing Agronomic and Special Crops.*

Extensive trials are being conducted with corn, cotton, tobacco, small grains and other crops.

(d) *Soybean Management Experiments.*

Large scale experimental work is now in progress with many phases of soybean production. The most important of these experiments are related to the production of soybeans in stubble following small grains.

(6) *Food, Nutrition, and Home Economics.*

The food industry is the largest industry in the United States, accounting for 25% of our national income. The research program is mainly designed to provide know-how for the establishment and successful operation of agriculturally based industries.

Problem Areas Being Investigated:

(a) *The Development of New Products Suitable for Production of Agriculturally Based Industries.*

An intensive program is underway to determine what new products can be developed from any of the products which we are producing in South Carolina.

(b) *Factors affecting the Nutritional Value of Foods and Feeds.*

Enrichment studies of corn meal, grits and rice have demonstrated the feasibility of enriching these foods which are low in nutritional value. The pioneering research in South Carolina has set a pattern which has been adopted by other states. This type of research will continue to improve the nutritive value of foods and feeds.

(7) *Grasses and Forage Crops.*

South Carolina is moving toward a livestock economy. Cotton acreage in recent years has been greatly reduced and many of the acres formerly used for cotton have been put in grass or planted to forage crops. The total value of grazing crops alone amounts to $132,000,000.00 annually. This value is increasing rapidly.

Problem Area Being Investigated:

At present, limited study is being made of adaptable forage plants for various conditions in the state.

(8) *Horticulture and Special Crops.*

Horticulture is important to the economy of South Carolina. The demand continues to increase for fruits, vegetables, and ornamentals. The United States Department of Agriculture predicts that we will need 40 per cent more truck crops and 33 per cent more fruits and nuts during the next 20 years. Home and highway beautification also continue to increase. Peach production has increased from 689,650 bushels in 1930 to over 5,000,000 bushels in 1958. The value of the crop to South Carolina growers is approximately 15 million dollars annually. The value of nursery products sold in South Carolina since 1940 has increased 529 per cent.

Problem Areas Being Investigated:

(a) *Mineral Nutrition of Peaches and Grapes.*
(b) *Evaluation of Varieties and Rootstocks—Peaches, Grapes, Vegetables, And Ornamentals.*
(c) *Chemical Thinning of Peaches.*
(d) *Weed Control in Ornamental Nursery Crops.*
(e) *Breeding Peppers, Sweet Potatoes, Southern Peas, Cantaloupes, Cucumbers, and Sesame.*
(f) *Cultural Practices with Peaches and Small Fruits.*
(g) *Post-Harvest Physiology of Fruits and Vegetables.*
(h) *Processing of Fruits and Vegetables.*

(9) *Insects and Parasites.*

It has been estimated that insects, plant diseases, and rodents cause 75 million dollars damage to farm crops and products each year in South Carolina of which over half can be attributed to insects. For example, recent investigations have shown that an animal free of cattle grubs will on the average bring $4.00 more than an infected animal. This would

amount to 2 1/5 million dollars for all of South Carolina's 400,000 head of cattle. Some recent figures show that forest insects and diseases cause a loss nine times greater than that caused by forest fires. The latest available figures indicate that the boil weevil cost the cotton producers of South Carolina approximately 25 million dollars annually during the six-year period of 1950-1955.

Problem Areas Being Investigated:

Work now under way includes projects designed to develop or improve control measures for destructive pests of peaches and other fruit, vegetable crops, cotton, tobacco, corn and small grain, forage and pasture, and forests and forest products. In addition general projects cover analysis of insecticide residues in crops and soils, surveys of potential pests, pollination by bees, and basic research in biology.

(10) *Plant Diseases and Weed Control.*

Total losses for the state from weeds and diseases are not available, but estimates indicated a $10,000,000.00 loss from the single disease rootknot in 1957. The use of soil fumigants and of new resistant varieties reduced this loss greatly within recent years and further reductions are indicated for the immediate future.

Problem Areas Being Investigated:

(a) *Peach Disease Studies With Emphasis on Root-knot and Bacteriosis.*

(b) *Small Grain and Perennial Pasture Grass Problems.*

(c) *Problems Associated with the Lack of Persistence of White Clover.*

(d) *Breeding for Disease Resistance in Various Crops.*

(e) *Disease Control in Ornamentals and Lawns.*

(f) *Weed Control in Row Crops and Pastures, with Emphasis on Cotton, Corn, and Soybeans.*

(g) *Disease Control in Vegetables with Emphasis on Cucurbits and Tomatoes.*

(h) *Disease Control in South Carolina Forests.*

(11) *Poultry.*

The Poultry industry represents a cash income of about $34,000,000.00 annually to South Carolina. In addition, it serves as an outlet for over 500,000,000 pounds of corn and 100,000,000 pounds of soybean meal annually.

Problems Areas Being Investigated:

(a) *Effects of Management of Turkey Males and Fertility.*

(b) *Effects of Feeds and Non-nutrient Additives on Egg Production, Hatchability and Growth in Chickens.*

(c) *Effects of Feeds and Feeding Methods in Growing Female Chickens and Their Reproduction and Livability.*

(d) *Studies in the Control of Certain Prevalent Diseases and Hemorrhages of Poultry.*

(12) *Soil Fertility and Fertilizers.*

South Carolina soils are naturally low in their content of plant food. Because of this, the farmers of South Carolina spend about 40 to 45 million dollars annually for fertilizers.

Problem Areas Being Investigated:

Much research at Clemson is directed toward the solution of cropping problems resulting from low fertility. Limited studies concerned with the improvement of the fertility of many soils of South Carolina are now under way. Crop rotation studies and the necessity for applying nutrients, as well as the determination of amounts to apply are being investigated.

(13) *Forestry.*

Forests occupy 12,015,800 of South Carolina's 19,404,500 acres. This means that 61.9% of the land area of our state is in forests. The commercial forest area is 11,934,900 acres. An extension of commercial acreage will have an immediate economic impact on the state.

Problem Areas Being Investigated.

(a) *Site preparation prior to tree planting.*

(b) *Direct Seeding of Pines and Grading of Trees for Reforestation Purposes.*

(c) *Fertilization of Loblolly Pines.*

(d) *Introduction of Exotic Species.*

(e) *Conversion of Inferior Stands to Valuable Ones.*

(14) *Miscellaneous.*

(a) *Methods, Techniques, and Sources of Water for Land Irrigation.*

(b) *Development and Maintenance of Drainage Systems.*

(c) *Crop Pest Commission Inspection, Quarantine, and Control Measures.*

(d) *Soil Testing Program.*

(e) *Methods of Water Conservation.*

II

Probable Future Research

(1) *The Nature and Causes of Low Fertility in Farm Animals.*
(2) *The Determinization of Effects of Additives (Antibiotics, Hormones, Tranquilizers) to Farm Animal Rations.*
(3) *The Determinization of Pelleting on the Utilization of Rations by Cattle, Sheep, and Swine.*
(4) *The Development and Evaluation of Selection Criteria for the Improvement of Production Efficiency and Market Quality of Farm Animals.*
(5) *A Study of Ultra-high-heat Treatments on the Physical, Chemical, and Bacteriological Aspects of Milk.*
(6) *A Study of Environmental Requirements for Optimum Germination of Seed.*
(7) *The Development of Automation for Farm Production.*
(8) *Chemical Determination of the Tobacco Leaf Under Different Growing and Processing Conditions.*
(9) *Product Development for South Carolina Vegetables and Fruits.*
(10) *Studies Concerning the Effects of Interrelationships of Nutrients and the Endocrine Systems of the Body on Growth, Health, and Longevity.*
(11) *The Development of Adaptable Varieties of Millets, Sorghum, and Grasses.*
(12) *Studies in Profitable Management of Forage Crops.*
(13) *Studies in the Mineral Nutrition of Woody Ornaments and Turf.*
(14) *Studies in Food Preservation Through Electro-Magnetic Radiation.*
(15) *The Development of Cytoplasmic Male-Sterile Strains of Peppers for the Production of Hybrids.*
(16) *Investigations Related to the Identification, Biology and Control of Such Pests as Eye Gnats and Ambrosia Beetles.*
(17) *Studies of Taxonomy and Biology of Raw Wood Infesting Insects.*
(18) *Disease Control Studies for Fruits and Native Pines.*
(19) *Studies of Nematode Problems.*
(20) *Studies in the Utilization and Processing of Poultry and Poultry Products.*
(21) *Development of New Uses for Wood Through Chemical and Mechanical Processes.*

(22) *Studies in the Agricultural Economy: e. g., Labor Requirements, Trends and Possibilities in Marketing, Economic Potential for New Agricultural Products, Determinations of the Optimum Size of Various Enterprises.*

EXHIBIT 5

EXISTING RESEARCH FACILITIES AT CLEMSON

(June 30, 1959)

I

ENGINEERING, ARCHITECTURE, THE PHYSICAL SCIENCES AND TEXTILES

A. *Engineering.*

The Clemson College School of Engineering is one of the largest and best equipped engineering facilities in the southeast. With adequate financing it could render noteworthy service through research and development projects. Such projects should be of immediate benefit to existing industries, as well as an aid in the attraction of new ones. This program could cover many areas of activity; *e. g.,* air pollution studies, increased utilization of the natural resources in the state, investigations of bearing capacity of soils in connection with highways and buildings, investigation of subgrade materials for heavy-duty highways, water supply and sewage disposal problems for industries and municipalities, and hydraulic and hydrologic studies.

As the following information will indicate, each of the six major areas of engineering at Clemson is or soon will be prepared physically for an expanded research effort. Additionally, it will be noted that four of the six areas have had or are having research experience in problems of interest to industry.

Ceramic Engineering. A grant from the Olin Foundation has provided Clemson with the nation's finest research facilities in Ceramic Engineering. These facilities include equipment for most research problems, basic or applied, which are associated with the ceramic industry. Basic research in the department is now carried out in connection with the graduate program, and has as its goal the development of new scientific knowledge without regard to specific commercial applications. Typical of the topics included in this program have been a study of why vermiculite exfoliates and a development of a new theory for copper-heading enamels. Although basic studies are not concerned directly with commercial developments, they often

provide new discoveries which are the basis of commercial developments. For instance, a study of the ion-exchange characteristics of vermiculite is now providing the impetus for a development of a commercial process of radioactive waste disposal using South Carolina materials. Similarly, the development of a new theory on the role of water during extrusion is now leading to the commercial sale of a by-product of a South Carolina paper industry.

The Ceramic Engineering Department has been active in development work, much of it in cooperation with the State Development Board. This work has had as its objective the increased utilization of the state's natural resources. Work done on shales provided the basis for a $3,000,000.00 expansion of our local clay products industry. Additionally, the department, through an extensive project, was influential in the location of the Kohler Company in South Carolina.

Chemical Engineering. As of September, 1959, the Chemical Engineering Department will be located in a new building and will have the equipment to perform research of interest to chemical and allied industries.

Currently the department is engaged in several projects, among them being:

(1) A three-year study of the characteristics of non-mechanical devices to replace mechanical devices in radio-chemical processing. (Sponsored by the Atomic Energy Commission.)
(2) A study of industrial waste treatment. (Sponsored by Owens-Corning Fiberglas.)
(3) A study of the uses and recovery of valuable materials from the fly ash of industrial power plants.

Civil Engineering. The Civil Engineering Department occupied its new quarters in September, 1958. This department has the equipment necessary to conduct research programs, basic and development, in many areas. During the past few years the department has carried out on a limited scale research projects which serve to demonstrate the possibilities for the future. Among these projects are:

(1) The use of local aggregates for economical concrete mixtures.
(2) Specifications as to the bearing capacity of various types of soils.
(3) The lagooning method of sewage disposal or small municipalities.
(4) A comparison of results from different techniques in aerial photography for mapping purposes.

Electrical Engineering. The laboratory facilities of the Electrical Engineering Department have been developed primarily for undergraduate teaching. However, certain items are suitable for both instruction and research, among them being:

(1) High-speed oscilloscopes and other related electronic equipment suitable for nuclear-instrumentation studies.
(2) Standard electrical measuring instruments and calibration equipment.
(3) Frequency and time-measuring devices suitable for measuring short time intervals or high frequencies with great accuracy.
(4) A hydraulic analog system suitable for providing design information for cities where water systems are being studied.

Engineering Mechanics. The Engineering Mechanics Department has equipment necessary to conduct research in two general fields: investigations of the use of solid materials as load bearing members; and investigations in hydraulic and hydrologic areas.

For the testing of solid materials, the more important items of equipment on hand are:

(1) Universal Testing Machines for uniaxial tension and compression loads and for bending loads.
(2) Torsional machines for measuring torisional deformation.
(3) Brinell, Rockwell, and Superficial Rockwell machines for the determination of the hardness index for almost any material.
(4) Fatigue machines for evaluating the fatigue strength and endurance limit of metallic materials and stress.
(5) A polariscope for qualitative and quantitative photoelastic studies.
(6) Strain gage equipment for static and dynamic studies.
(7) Photostress equipment for qualitative and quantitative stress analysis.

For hydraulic investigations a laboratory area of 4,500 square feet is available. This laboratory was designed for maximum flexibility of operation and provides an extensive capability for research in fluid flow. Basic studies of flow in open and closed channels as well as the determination of the performance characteristics of hydraulic machinery can be undertaken.

Mechanical Engineering. The facilities available to the Mechanical Engineering Department which can be used for research consist primarily of instruction. Instruments are available for measuring the

heating value of gaseous fuels, the very rapidly-varying pressures of gases in containers, and the very rapidly-varying gas velocities. In addition, the department has on order the necessary equipment for basic investigations necessary for predicting performance in high altitude rocket and missile work.

An example of the work that has been done is an investigation of air pressure drops in Sonotubes and the measurement of the coefficient of heat transfer of the material of which Sonotubes are made. (Sponsored by Sonoco Products Company.)

Engineering Recommendations.

(1) In order to develop and expand the research activity of the School of Engineering some additional supplies and equipment would be required, but the primary need would be for an increase in research-trained staff. To allow our present staff members time for research, and to secure additional personnel for either full-time research or part-time teaching and part-time research activity, will require an initial budget of approximately $100,000.00. Of this, approximately $80,000.00 will be required for staff and $20,000.00 for supplies and equipment.

(2) The research effort of the School of Engineering should be organized on an Experiment Station basis, with a full-time director. The salary, secretarial and incidental expenses of this director would be about $15,000.00 annually.

B. *The Physical Sciences.*

At Clemson these include Chemistry, Geology, and Physics. Research in these areas has been done by men employed solely as teachers; hence research has been an after-hours interest. Nonetheless during the past five years four chemists, one geologist, and four physicists have compiled noteworthy research records. Five of these men, on their own initiative, have recently obtained government research grants; and one, a geologist, is currently carrying out a project supported by the State Development Board.

Research done in the physical sciences has been to a large degree basic, and the projects have reflected researchers' individual interests. This has resulted in a variety of studies including mineral surveys, the determination of fluorides in water, the possible use of chemicals as arresting agents for human cancer, spectrographic studies of human gall stones, and the development of a low temperature x-ray camera.

Given additional funds for the purchase of necessary materials and the employment of skilled staff assistance, the physical science areas could expand research to a point where direct and/or indirect benefits would accrue to the state's industrial development. In addition, the Chemistry and Physics areas could increase graduate instruction, thus training men and women to work effectively in the state's industrial laboratories.

It should be emphasized that research in the physical sciences would serve as a vital correlate to sponsored research which would be done in Engineering, Agriculture, and elsewhere. Cooperative effort of this sort, which has not been fully possible in the past, depends in large measure on the freeing of research time to physical science investigators.

The Department of Chemistry is housed in a modern building with laboratory facilities which range from very good to excellent, both for current uses and for expanded research activities. Especially significant in this connection is the radioisotope laboratory, perhaps the finest in the Southeast.

The Chemistry Department has awarded Master's degrees for ten years and will offer courses this fall leading to the research doctorate. The department has recently been granted four National Defense three-year fellowships by the federal government.

The head of the Chemistry Department believes that an additional annual appropriation of $27,000.00 would enable him to employ two additional research-teacher chemists and provide them with necessary chemicals, equipment and instruments. This, in turn, would enable the department to seek and carry out research projects which could have an impact on the state's economy.

Geological teaching and research at Clemson is conducted by two men, under the administration of the Department of Chemistry. Geological surveys of mineral resources in South Carolina could be undertaken by these Clemson Geologists. A survey of Oconee County resources is currently being made by one of them. $10,000.00 per year will be required to meet travel and general expenses if this work is to be expended.

The Department of Physics does not at present have adequate physical facilities for expanded research. However a new building will be constructed, beginning in 1960, and will include laboratory space sufficient for academic and research programs.

Research now being done by Clemson physicists includes nuclear studies, work with x-ray, and electronmicroscopic photography. The department conducts an excellent graduate program.

The department head believes that, with completion of the new building, additional basic research could be undertaken in physics. He estimates that an additional appropriation of $20,000.00 would allow implementation of the expanded program. The bulk of this money ($17,000.00) would go toward the employment of staff assistance. The remaining $3,000.00 would purchase special equipment essential to projects under investigation.

C. *Architecture.*

The School of Architecture serves South Carolina industry by training professional architects or work within the state; and by offering leadership in the theory and practice of building design and community planning. Beginning in September, 1959, the school expects to offer work leading to the six-year Master of Architecture degree. This step will enable the school to enlarge its prestige and its service.

Facilities for creative work in Architecture are excellent. The new Architecture Building, completed late in 1958, is adequate for current and expanded programs. The staff of the school is capable and professionally experienced.

Industrial research as such is not normally a function of Architecture; nonetheless architects can and do engage in consultant studies which are valuable in attracting and holding industry.

One logical field of consultant study for architecture is that of town, regional, and non-urban planning. This work could be undertaken with the State Development Board as a cooperative agency.

Another appropriate and timely area is that of design and/or development of building materials for the building industry. This could vary in scope from the design of an elementary building unit to that of design and development of an entirely new material or new application of an existing material. In some cases, collaboration with adjunct sciences and technologies such as chemistry, ceramics, forestry, or textiles would be required.

The Clemson School of Architecture recommends that it enter the areas of developmental research outlined above. Should the School enter these fields on an extensive scale, the Architecture staff would require enlargement. In the initial stages, two full-time staff members

would suffice. Salaries and incidental office and research expenses for these men would amount to $22,500.00 annually.

D. *Textiles.*

Research and testing has been a recognized activity in the School of Textiles from its inception. Since World War II this work has been expanded. In January, 1958, a separate textile research department was authorized and established.

Accomplishments in textile research at Clemson include more than fifty separate improvements in textile machinery; more than thirty published studies of electronmicroscopic investigations of cotton fibers, and numerous classified (industry sponsored) projects of varied type. Noteworthy experimental work has also been done in spinning and bleaching. Several of these programs were supported by grants from the U. S. Department of Agriculture. Others were and are supported by the Sirrine Textile Foundation and by individual textile concerns.

The value of this varied research to the textile industry has been considerable. This is attested to by continuing industrial interest in and support of the research activities.

Facilities for textile research at Clemson are superior. The Textile Building is modern and contains laboratories adequate for expansion. These laboratories are supplemented by the presence on campus of the Agricultural Experiment Station, the USDA Southeastern experimental gin, and the USDA 1000-spindle spinning facility. These several units, working in harmony, make Clemson the center of cotton research in the United States.

The staff for research in textiles is administered by the school dean via the head of the school research department. This research department employs a few professionally trained people for fundamental work and a few technical assistants for routine tasks. These people are paid largely from sponsored research income.

This small permanent research staff is supplemented by graduate students and by the regular teaching faculty, especially during the summer months.

Although the conducting of industrially sponsored research is important and will be continued on an increasing level, Clemson College must provide leadership in the investigation of basic textile problems, such as the development of new products. In order to proceed with this vital work, the Textile Research Department requests state funds.

The Dean of the School of Textiles and the Head of the Textile Research Department estimate that an original appropriation of $55,000.00 is required. This money would be spent for staff additions, for technical assistance, and for continuing expenses incidental to the program.

II

The Need for a Data Processing and Electronic Computing Center

During the past decade the high speed computing machine has begun to have a profound impact on modern science and technology. Scientific problems which were previously beyond the capacity of desk calculation can now be solved in hours or days.

Among the general research tasks which such machines perform are these: rapid analysis of masses of data; calculation of means and standard deviations; analyses of variance; studies of correlation and regression; and solution of simultaneous equations.

Typical research problems at other institutions which have been solved or which are being worked out with electronic computers are:

In Applied Research.
Cost accounting.
Airline scheduling.
Study of inventory problems and production records.
Simulation of communication networks.
Probability of power outages.
Calculation of insurance expectancy tables.
Design of fractional horsepower motors.
Farm organization and management problems.
Estimates of genetic parameters in plants and animals.

In Basic Research.
Fourier analysis of x-ray diffraction information.
Inverse cumulative binomial distribution tables.
Intrinsic luminosity calculation for G.S. stars.
Solution of radial Schroedinger equation.
Numerical conformal mapping.
Research in eigenvector and eigenvalue calculations.
Simulation of computer logic.

If Clemson is to expand existing research programs and introduce new ones, a data processing and computing center must be established on the campus. In the beginning this center could operate with

one of the smaller "memory" machines, with card-to-tape conversion facilities. The cost of a typical machine and auxiliary equipment necessary to its effective operation will be $42,493.00. Maintenance costs will be $3,195.00. The salary and office expenses of a full-time computing center director will be approximately $10,000.00. Thus the total appropriation required to establish a minimum electronic computing center at Clemson will be $55,688.00. Of this amount, $13,195.00 will be an annual budget item.

III

An Expanded Graduate School

The Graduate School exists for two central purposes: to coordinate programs aimed at training researchers and highly specialized personnel for teaching and for industrial service; and to develop an atmosphere of scholarship and research on the Clemson campus.

Graduate students serve as research assistants in each of the teaching schools except architecture. As such, these students aid materially in the accomplishment of research goals.

An expanded research effort at Clemson will demand an expanded Graduate School. This, in turn, will mean that stipends offered students as graduate assistants must be raised; and that the number of such assistants must be increased. In areas where the doctorate is and can be offered, fellowships must be established.

The Graduate School recommendations are:

(1) That the present number of graduate assistants be increased from 50-60 to a minimum of 75; and that the academic year stipend paid to each assistant be increased from $1,400.00-$1,800.00 to a minimum of $2,000.00; and

(2) That a minimum of two graduate fellowships of $2,400.00 each be supported by state funds in each of the doctoral areas. Currently the doctorate is awarded in Agricultural Economics, Chemistry, Entomology, and Plant Pathology.

IV

The Maintenance of Research in Agriculture

In accord with its clearly defined dual function of teaching and public service, the School of Agriculture at Clemson has carried out, through the experiment station, a varied program of applied and basic research. This research has been supported with funds from the county, state, and federal governments, and from other sources.

The research output of the School of Agriculture has been large. More than 1,200 articles, leaflets, bulletins and books have been written and disseminated by Experiment Station personnel. Although the bulk of these studies have been utilitarian, important basic research has been done in food preservation, soil chemistry, animal breeding, crop improvement, irrigation, plant diseases, insect control, and the development and improvement of fruit and vegetable strains. More than two hundred projects of all types are currently in progress.

Staff and physical facilities for research in Agriculture are excellent and adequate for the current programs. The laboratories are modern and equipped for projected expansion of research activities.

The recommendation of the School of Agriculture is for the continuation of state supported research at no less than its present level. This recommendation is not an implication that existing programs in Agricultural research are sufficient to resolve all the problems of importance to the farmers and farm industries of South Carolina. Agriculture is and will be in every sense an industry of extreme importance to the total economy of the state. Research and experimentation is its lifeblood and must continue to be expanded where feasible.

Current and future research in South Carolina agriculture is planned along these six major lines:

(1) The improvement of marketing and distribution practices for all agricultural products;

(2) The reduction of losses due to insects, diseases, parasites and other pests;

(3) The development of new crops and new uses for existing crops;

(4) The improvement of the quality of food, feeds, and other agricultural products;

(5) The improvement of methods and systems for producing and handling dairy cattle, beef cattle, swine, sheep, and poultry; and

(6) A survey and evaluation of soils, plants, and water resources.

EXHIBIT 6

PROPOSED EXPANDED RESEARCH PROGRAM AT CLEMSON

(June 30, 1959)

In order to expand and improve its existing basic and applied research programs, with a view especially toward bettering the social and economic welfare of South Carolina, Clemson College recommends the following:

A. *Engineering.*

An appropriation of $115,000.00 to establish an Engineering Experiment Station at Clemson.

B. *The Physical Sciences.*

An appropriation of $57,000.00 to inaugurate a program of basic and applied research in the areas of Chemistry, Geology, and Physics.

C. *Architecture.*

An appropriation of $22,500.00 to inaugurate consultant study in town, regional, and non-urban planning for South Carolina; and applied research in the design and/or development of building materials.

D. *Textiles.*

An appropriation of $55,000.00 to undertake basic textile research, under administration of the Textile Research Department.

E. *Data Processing and Computing Center.*

An appropriation of $55,688.00 to establish an on-campus electronic data processing and computing center.

F. *Graduate School.*

An appropriation of $85,200.00 to provide doctoral fellowships, additional graduate assistantships, and increased stipends for existing assistants.

G. *Agriculture.*

The continuation and expansion where feasible of state-supported research programs.

H. *Total.*

A total appropriation of $390,388.00 is recommended for implementation of an expanded research program at Clemson College.

EXHIBIT 7

RESEARCH ACCOMPLISHMENTS IN AGRICULTURE AT CLEMSON

(October 1, 1959)

1. *The Production of Meat-Type Hogs.*

During the years 1955-1957, 68 hogs were fattened in individual pens in dry lot and checked for meat-type certification. The hogs which met all requirements for certification required 19 pounds less feed per 100 pounds of gain and produced carcasses which had a yield of one per cent more of the lean cuts. Based on these data, we can now recommend the production of meat-type hogs inasmuch as they convert feed to pork more efficiently than the fatter hogs and also give a higher yield of lean cuts. The gross income for hogs for 1958 was $30,607,000.00. According to the best information that we have available we now produce a little over half of the pork consumed in South Carolina; therefore, it is reasonable to estimate that we may be able to increase our gross income by at least another $5,000,000.00 by the use of meat-type hogs.

2. *Winter Forage for Fattening Steers.*

Three years' work has been completed during which steers were fattened in dry lot, on winter forage, and on winter forage with supplemental feeding. The feed costs per 100 pounds of gain was $19.44 for the steers fed in dry lot and $7.08 for those getting forage without grain. Depending on the grain or concentrate mixture used, the feed cost per 100 pounds of gain for the steers fed on forage ranged from $10.41 to $13.73.

All carcasses were similar in grade, calculated separable bone, fat, lean, and percentage of fat (marbling) of the rib eye as well as the area of the rib eye.

The gross income from cattle and calves for 1958 was $25,733,000.00. Since we produce approximately half of the beef consumed in South Carolina, it is estimated that by using this system of fattening cattle, we might increase our gross income an additional $5,000,000.00.

3. *Crossbreeding for Fat Calf Production.*

Birth weights, 210-day weights and slaughter grades were secured on 310 calves produced during a six-year period (1948-1953). When Angus animals were used, the average weaning weight was 507.30

pounds as compared to 561.53 pounds for calves from Angus dams sired by Hereford bulls. Therefore, there was an increase of 54 pounds per calf in favor of the crossbreeds. Inasmuch as there is considerable fat calf production in South Carolina, it is estimated that this may add to the gross income approximately $1,000,000.00 annually.

4. *Feeding Steers on Coastal Bermuda Pasture.*

One year's work has been completed and another is in progress in which four steers are stocked per acre on Coastal Bermuda pasture, and these animals are fed concentrates in addition to the pasturage obtained. The feed costs per 100 pounds of gain were $24.55 for the steers fattened in dry lot and $14.19 for those fattened on forage. Results indicate that steers can be finished to a desirable slaughter grade when fed on Coastal Bermuda pasture. Using this system of fattening cattle, it is possible to add to our economy an additional $5,000,000.00 annually.

5. *Fattening Lambs on Winter Forage.*

One year's work has been completed in which nursing lambs were fattened on winter forage. These lambs consumed very little feed in addition to the forage and the ewe's milk; however, they made excellent gains and most of the carcasses graded Choice. Since South Carolina is reasonably close to the center of the lamb consumption area in the United States, it appears that we are in a very desirable location to further the production of early lambs.

6. *Use of Molasses in Dairy Cattle Feeding.*

Detailed feeding trials at Clemson College have outlined the best methods for feeding molasses on the farm and the amounts to feed to heifers, dry cows, and milking cows. A tractor-drawn molasses trailer has been developed as a practical method of feeding. Molasses, fed in amounts of 8 to 10 pounds per day, can substitute for 6 pounds of concentrate or replace 30 pounds of silage in the milking cow ration. The studies have included the mixing of urea and urea-phosphate feeding solution with molasses. Digestion and balance studies have been conducted to more exactly show how well the molasses products are used by the animals.

Since 1951 an increasing amount of alcohol has been produced from petroleum products. This continuing change has released large amounts of blackstrap molasses for feeding purposes which was formerly used in fermentation processes. In fact, livestock feeding is about the only way to use the surplus. After the 1954 drought in

South Carolina, the bulk feeding of molasses increased tremendously, with the total sales increasing at least threefold. Because of the drought, corn production was low and our experiments up to that time were far enough along for the college to show the farmer how to replace farm grains and silage with molasses. Otherwise, a much larger amount of higher priced feeds would have been shipped in from other markets. Two publications have been released and two more will soon be issued. Commercial molasses companies in the mid-west and the west coast have purchased a supply of our publications. Our research is being applied in Hawaii and India.

7. *Studies on Vacu-Therm Pasteurization.*

Onion-flavored milk was treated under vacuum in the DeLaval Vacu-Therm pasteurizer. The milk was pasteurized at 175°F., at which temperature it entered the vacuum chamber, where it flashed immediately under reduced pressure.

The results of these studies indicate that onion flavor, plus other volatile flavors can be removed by treating milk in Vacu-Therm equipment. The presence of these off-flavors in milk make it rather difficult for plants to sell their milk. If this milk is received from producers, it is necessary that it be rejected because of its ultimate effect upon the consumer. Not only does this equipment remove these off-flavors, it also tends to standardize the flavor of milk eliminating this important characteristic of milk to mere chance.

Vacuum pasteurizers have been a boon to South Carolina dairy plants. One plant reported that during a single onion season, it lost enough sales to pay for the vacuum equipment. Another of the larger plants in the state estimated that a loss of $31,000.00 in sales could be experienced in one day due to off-flavors in milk. Since this study has been completed, most of the larger dairy plants have installed vacuum pasteurizers.

8. *Studies of the Quality of Milk Retailed in South Carolina.*

Samples of milk purchased in retail outlets representing the milk of each plant in the state were analyzed monthly for a calendar year for butterfat, milk solids-not-fat, total milk solids, freezing point value, phosphatase value, and fill of container. State averages were 4.0% butterfat, 9.0% for milk solids-not-fat, and 13.0% for total milk solids. Six per cent of samples failed to meet state standards for butterfat. About 1.5% of samples failed to meet state standards for milk solids-not-fat, while 2.5% did not meet state standards for total milk solids. Over 50% of the samples did not meet state requirements

for fill of container. About 15% of the samples were inadequately pasteurized.

Few samples were found to be in violation of standards which are commonly enforced. The reverse was true for standards which are not commonly enforced. Some standards are unrealistic in spite of adequate information while others need adequate information in order to establish reasonable values. This research provided background material, previously nonexistent, on which the feasibility of research concerning a method of paying milk producers on a total solids basis may be determined. It emphasizes the need for good, simple tests which regulatory agencies may employ. Such tests have been proposed to the state as a result of this work, thus protecting producers from an unfair standard and giving regulatory personnel a value with which they may work in confidence.

9. *Evaluation of Coastal Bermuda Grass for Hay and Grazing.*

Coastal Bermuda grass hay has been compared experimentally to alfalfa, common Bermuda, and oat hays. When the main forage for milking cows was made up of hay supplemented by corn silage, Coastal Bermuda hay was worth 87% of alfalfa hay, common Bermuda hay was worth 93% and oat hay cut in milk stage, 86%. Another system of feeding was tried in which corn silage was fed to milking cows as the main forage and was supplemented by the hays. Oat hay cut in bloom stage was worth 102% of alfalfa hay, Coastal Bermuda hay, 95% and common Bermuda hay, 97%. The unusual importance of proper fertilization, growing, and curing is emphasized by the low TDN content of improperly cured hay being 46.6% compared to 53.9% for properly cured hay.

Pasture studies have shown that rotational grazing is a much better system than continuous with Coastal Bermuda grass. High yields of 3,600 pounds of TDN per acre were obtained. Irrigation increased the yield to 4,900 pounds per acre.

The actual and potential values are difficult to estimate. In six years, Coastal Bermuda acreage has increased rapidly in South Carolina. Historically, until 1958, the average hay yield in South Carolina has never averaged even 1.0 ton per acre. Experimentally, the yield of Coastal Bermuda hay in three years averaged 4.6 tons with a high of 6.7 tons. Test demonstrations have yielded up to 15 tons per acre.

10. *Frozen Semen Research.*

Clemson initiated an artificial insemination program for dairy cattle in South Carolina in 1945. By 1950, 9,000 cows per year were being artificially inseminated to semen collected from bulls of the Clemson Bull Stud which was operated by the Clemson Dairy Department. By 1955, this number had increased to some 12,000 cows. As a result of this Dairy Department program, an improvement in type of dairy cattle and the amount of milk produced per cow began to be observed on our farms.

Successful as this Clemson program was, it was generally felt by 1957 that it had outlived its usefulness. The reason for this was very simple. Large bull studs, breeding around 200,000 cows or more per year, can afford better bulls and operate more economically than can a stud such as Clemson's, breeding less than 15,000 cows per year. The time had come for a progressive change. On the basis of research begun in 1954, South Carolina farmers were advised in 1957 to accept a frozen semen program.

Semen in an ordinary diluter, with glycerol added, may be frozen to 110°F., with dry ice and alcohol and at that low temperature will maintain livability for periods of up to at least six years. To the farmer, this means selecting any bull that he wants at any time since a county inseminator stores all stud bulls at all times.

In 1958, 20,000 cows were artifically inseminated in South Carolina. Actual values in this type of work are difficult to determine. Frozen semen has expanded our artificial breeding program and has further improved our cows. In approximately two years of operation, it has conservatively increased value of female offspring, some 20,000 by $50.00 each, giving a total value of $1,000,000.00. This figure does not take into account any future increase in milk yields by these 20,000 heifer calves.

11. *Increased Milk Production from Crossbred Cows.*

Crossbred cows in the Clemson College herd from Guernsey cows and sired by Holstein bulls have consistently produced more milk and butterfat than their dams. When the Crossbred females were mated to Brown Swiss bulls, their daughters showed an additional average increase of 240 pounds of milk. Based on these results, many South Carolina dairymen have bred their grade Guernsey and Jersey cows to Holstein and Brown Swiss bulls. By following this procedure, milk production has been increased and the butterfat test lowered.

12. *Economic Outlook and Potentials Studies.*

The Department of Agricultural Economics at Clemson has conducted a series of studies which fall under the heading of "Economic Outlook and Potentials." Some of these have been at the request of Chambers of Commerce or other promotional groups. Quite a few bulletins and reports have been published detailing the results. A few representative titles include: "The Postwar Economic Outlook in an Agricultural-Industrial Area"; "A Brief Economic Study of the Anderson (S. C.) Trade Area"; "Postwar Employment Opportunities in an Agricultural Community"; "The Economic Outlook in Sumter, South Carolina"; "An Economic Study of the Columbia Farm Trade Area"; "An Agricultural Production, Consumption and Marketing Study in the Greenville (S. C.) Trade Area"; "A Statistical Study of Agriculture and Related Trends"; "A Pattern of Agricultural Production in South Carolina After the War"; "Farm Possibilities In Horry County"; "A Graphic Summary of Agricultural Change in South Carolina"; and "Livestock, Dairy and Poultry Statistics".

These studies have been backed up by a vast assembly of agricultural and related data (the collection of which is one responsibility of this department) and by the wide economic experience of our staff members. Briefly, the results in general indicate the nature of our economy, the basic underlying trends, and the opportunities (and problems) we face in the future.

13. *Population-Resource Studies.*

Under the heading of "Population-Resource Studies", we have completed and published a number of reports designed to show such things as factors associated with high level employment and optimum use of resources, agricultural-industrial inter-dependence, the place of part-time farming in the economy, public requirements for certain services, tax situation and means of improvement, problems of fringe areas, sources of industrial labor, and obstacles to economic improvement. For one thing, these studies show that agriculture in this state is producing more workers for agri-business than for farming. Also, labor on farms is reluctant to "move" more than 15 miles for a better job.

We cannot begin to evaluate in dollars and cents the results of these studies, but I can state that a large industrial plant at Rock Hill was a direct result of information obtained during these investigations.

14. *Agricultural Adjustment and Farm Efficiency Studies.*

Over a long period of time, this department has conducted numerous studies aimed toward the goal of increased efficiency and income for farmers. A good part of this particular research in recent years has been in the fields of agricultural adjustments, production requirements, sources and uses of credit, farm costs and returns. For these studies we have built up a mass of information which permits a "budget analysis" of various alternative farming systems and individual enterprises showing producers what they can expect in the light of known information. Incidentally, this same information enters into the determination of the "parity formula" and the determination of rates and benefits for government crop insurance.

No attempt will be made to provide an aggregate evaluation of the results of these studies. Individual instances can be shown where farmers making the changes suggested could increase their income by as much as 1000 per cent.

15. *Marketing Problems, Needs and Facilities.*

South Carolina farmers sell approximately $400 million worth of produce annually and spend about three-fourths as much for things they need. One of the important items of farm expense is fertilizers, for which our farmers pay about $40 million annually. A saving of even 10 per cent in this item is worth $4 million to the state's farm economy. Research in the Department of Agricultural Economics has demonstrated possible savings of *twice* this amount.

Another area of research into marketing problems is in means for reduction of losses from improper handling. One potato grower in South Carolina reports that one such study saves him $3,500.00 every day he harvests potatoes. The Department has also conducted studies designed to reduce costs and increase returns in marketing tomatoes, beef cattle, hogs, milk, eggs, etc.

In addition, we have studied the economic feasibility of certain proposed market facilities and processing plants. The value of such services derives not only from facilities which are established and function successfully, but also from those which might be established. Altogether, we have made and published results of about a dozen such surveys. In addition, we have provided (In cooperation with the Crop Estimates Division, USDA) the statistical data which are essential to an adequate appraisal of market needs, both from the supply and the demand side.

16. *Seed Harvesting Losses.*

Investigations were made to determine the effect of various factors influencing seed harvesting losses in the Southeast. Seed losses were found to occur from weather shatter, cutterbar, and combine.

The Southeast's production of crimson clover, fescue, and lespedeza seed is over $12,000,000.00 annually. A conservative estimate of average harvesting loss in these crops would be 25 per cent. Improved harvesting practice could easily eliminate 10 per cent of this loss.

17. *Minimum Tillage and Mechanization Related to Corn Production.*

The cost of corn production by minimum tillage has been reduced by 20% in experiments at Clemson. This cost was reduced by eliminating disking following plowing by use of chemical weed control and combine harvesting.

If the cost of producing corn could be applied to similar land and crop situations for 20% of the corn planted in South Carolina, then this would amount to a net saving of over $300,000.00 annually.

18. *Subsoiling for Increased Corn Yield.*

Subsoiling increased the value of corn produced in experiments at the Edisto Station. Corn yield on Norfolk and Marlboro sandy loam soils were doubled in 1958 by subsoiling 16" deep prior to planting.

Doubling the yield of the corn crop in South Carolina would increase the economic returns to the farmer by $4,500,000.00 annually.

19. *The Soil Testing Laboratory.*

The Soil Testing Laboratory at Clemson had its beginning in 1930. The laboratory was set up to analyze soil samples sent in by the farmers of South Carolina. At present, their pH value and their available P_2O_5 and K_2O contents are determined.

Since its organization, the laboratory has analyzed about 2½ million samples of South Carolina soils. In recent years the analyses of these soils have been returned to the farmers through their county agents' office and the county agents have recommended suitable applications of fertilizers based on the analysis of the farmer's soils, the history of the field involved and the crop the farmer desired to grow.

As a result of these analyses and recommendations, $1,000,000.00 annually has been added to the income of farmers of the state.

20. *Release of Anderson and Taylor Wheat Varieties.*

In 1953, seed of Anderson and Taylor wheats were released by the Department of Agronomy and Soils for fall planting. These two

wheats have been outstanding in their adaptation to the conditions which we have here in South Carolina. The Anderson variety of wheat is now the leading variety grown in the state. Taylor occupies a lesser acreage and is grown mainly in the Piedmont.

Wheat yields in South Carolina have increased from 16 to 22 bushels per acre since 1953, and it is felt that this increase in yield has been largely the result of the introduction of the two above-named varieties. These two varieties return $2,000,000.00 annually to the farmers of South Carolina.

21. *Release of the Jackson and Lee Varieties of Soybeans.*

The Jackson and Lee varieties of soybeans were released to the public by the Department of Agronomy and Soils in cooperation with the USDA and some of the other Southern Experiment Stations in 1953 and 1954, respectively. Both of these varieties of soybeans have a high oil content. The Jackson variety is now planted on approximately 25 per cent of the acreage of the state. The Lee variety probably makes up about 15 per cent of the soybean acreage of the state. The total acreage planted to soybeans in South Carolina this year was about 451,000 acres. The value of these two varieties annually amounts to $400,000.00.

22. *Grazing Experiments with Beef Cattle.*

About 100 acres of land at the Edisto Station has been devoted during the last three years to a project in which a comparison is being made between the grazing capabilities of Common and Coastal Bermuda grasses and Bahia grass. Results today show that 1,000 pounds of beef per acre can be made from Coastal Bermuda grass in the Edisto area where an application of 400 pounds of nitrogen and suitable quantities of phosphate and potash are applied.

23. *Studies of the Basic Chemical, Physical, and Clay Mineral Properties of South Carolina Soils.*

Investigations are now underway of the properties of different soil types found in South Carolina. These studies are expected to provide needed information for more efficient fertilization of South Carolina crops and a better classification of the soils of the state.

24. *A Soil Survey of South Carolina.*

The South Carolina Experiment Station, in cooperation with the Soil Conservation Service of the USDA, has been for a number of years, in the process of surveying the soils of South Carolina. Already a map of the state has been published showing the land use areas of

the state and individual counties are now being surveyed and these results will be published in bulletin form.

25. *Irrigation Requirements of South Carolina Soils.*

This study was conducted in cooperation with the USDA. Infiltration rates of different soil types and the amount of available moisture which these soils can store at various depths have been determined.

This information now provides the basis for designing irrigation systems in South Carolina with respect to the number of applications of water and the amount of water to be applied at each irrigation. It has been incorporated in the "South Carolina Sprinkler Irrigation Guide" and similar publications in adjoining states. The information secured is used extensively by Soil Conservation workers, Soil Extension workers and irrigation equipment engineers in South Carolina. It is estimated that this information increases income to farmers in South Carolina by $1,000,000.00 annually.

26. *Irrigation Experiments with Field Crops.*

Irrigation experiments with cotton, corn, sweet potatoes, tobacco, Bermudagrass and alfalfa have evaluated the response of these crops to supplemental irrigation and the interrelations of irrigations and fertilization.

Experiments with tobacco at the Pee Dee Station evaluated the effects of different levels of chlorides in irrigation water on yield and quality of Bright tobacco. Chemical analysis of a large number of irrigation sources in the tobacco section showed that most of the ponds, streams, and wells tested do not contain enough chlorine and calcium or other chemical substances to have an injurious effect on the quality of the bright tobacco irrigated with them. Studies of the use of brackish water for irrigating truck crops at the Truck Station at Charleston have established some of the limits of salt concentration that can be tolerated by specific truck crops without serious injury.

27. *Studies with Minor Chemical Elements.*

On the basis of research that has been conducted by the Department of Agronomy and Soils, the form in which boron is applied as a fertilizer has been changed from a soluble to a slowly soluble compound. These slowly soluble compounds provide a more constant supply of boron to crops and minimize both leeching from the root zone and toxicity to plants in the feeding stage. Studies have also shown that boron and manganese should be incorporated in the commercial fertilizers of the state that will be applied to cotton. Increases in the

yields of cotton have been noted in many counties. The use of this information is estimated to increase income in South Carolina by $3,000,000.00 annually.

28. *Variety Tests of Field Crops.*

Variety tests with cotton and corn, small grains, soybeans, peanuts and other field crops have been conducted annually by the Department of Agronomy and Soils. From the results secured in these tests, crop variety recommendations have been made to the farmers of the state. These results have allowed the farmers of the state to plant the varieties best adapted to conditions in South Carolina. These tests save the farmers of the state an estimated $3,000,000.00 annually.

29. *Cured Smoked Turkey.*

Consumer acceptance taste tests have shown that cured turkey is well liked and that it will be a popular item when made available at reasonable prices. The optimum conditions for curing, smoking, and roasting have been determined and yield data obtained which makes it possible to determine processing costs. Dressed turkeys are cured in a brine-sugar-nitrite solution similar to that used in curing ham. They are then smoked and roasted.

South Carolina produces many turkeys and can produce many more than at present, provided markets are available. The turkey is a most efficient bird, yielding more meat per pound of feed than almost any other meat-producing animal. Curing and smoking gives a turkey product with a taste appeal which should result in new outlets for turkeys and a margin of profit for the processor.

30. *Convenience Mixes for Baking.*

Convenience mixes have been developed utilizing South Carolina corn meal. Formulae have been worked out which contain all ingredients required to produce delightful cakes, cookies, muffins, and bread. The user need add only water in preparation for baking.

This accomplishment is important to South Carolina, since it means that the know-how exists in the state for producing convenience type mixes for a variety of baked products. This information will be available to those interested in establishing this kind of food processing industry in South Carolina.

31. *Grape Products and Processing.*

Dozens of varieties of grapes grow in South Carolina have been processed into juice by several methods. Taste tests have shown that some of these varieties have color and flavor characteristics which

are desirable in a beverage type juice. Cold pressing has been shown to preserve the fresh flavor of the fruit whereas this is destroyed in some varieties of hot pressing.

32. *Nutritional Improvement of Southern Staple Foods.*

South Carolina was the first state to require by law the enrichment of margarine, flour, bread, corn meal, grits, and rice. The food value of these products has been decreased by refining, and enrichment adds many of the essential vitamins and minerals without affecting their taste or cooking quality. Premixes containing the vitamins and minerals, and machines to add them to these cereals have been developed by Clemson College and are available to millers in South Carolina and other southern states. These premixes and machines are especially adapted for use with small corn mills so that all the corn meal produced in South Carolina can be nutritionally improved quickly and inexpensively.

The far-reaching beneficial results obtained from improved nutrition cannot be expressed in dollars, yield per acre, or man days worked. It is reflected in the improved health and work capacity of all our population.

33. *Development of Clemson Spineless Okra.*

The Department of Horticulture initiated an okra breeding program in the early 1930's. Workers on this project received a sample of seed for testing which was obtained from spineless pods. By selecting and testing plants from this segregating okra population, a uniform strain possessing dark green and spineless pods was introduced in 1938 and was named Clemson Spineless. It received a Silver Medal Award in the 1939 All-American Selections of the American Seed Trade Association.

Since its introduction, Clemson Spineless okra has become well known to every seedsman, trucker, and home gardener. Under normal conditions, it produces as much as 10,000 pounds of fresh pods per acre. Over 13 million pounds of fresh okra are packed and frozen annually in the South. Clemson Spineless is the leading variety for processing and fresh market in this area.

34. *Mildew Resistant Cucumber.*

Diseases caused a sharp decline in cucumber production in the South during recent years. Research workers at the Clemson College Truck Station in Charleston have successfully combined good fruit and plant characters of American varieties with the downy mildew

resistant varieties imported from foreign countries. A downy milldew resistant cucumber with superior fruit color, shape, and size was released by the South Carolina Agricultural Experiment Station in 1956.

This variety (the Ashley) has been well accepted by growers and the cucumber trade, not only in the South, but in other areas as well. Reports indicate that western seed and market growers have found the powdery mildew resistance of Ashley to be of great value. Northern growers are finding its earliness and superior fruit color a real asset. Southern growers are finding its downy mildew resistance so good that fungicides are not needed in the spring. It also grows well in the fall even when rains prevent the use of a proper fungicide program. The gross income from the fall crop alone totals $1,000,-000.00 annually.

35. *Edisto Cantaloupe: A New Variety for the South.*

Serious disease epidemics are responsible for a total loss of extensive plantings of muskmelons or cantaloupes in many areas of the South. Edisto, a new disease-resistant, attractive, highly colored, good quality cantaloupe variety was released by the South Carolina Agricultural Experiment Station in 1957.

Edisto shows promise of fulfilling the need for a thick-fleshed, jumbo-size, truckers-type cantaloupe that can be depended on from year to year. In addition to Edisto's attractiveness to the consumer, the rind is exceptionally hard which enables the trucker to transport the cantaloupes to the consumer with less damage. From the grower standpoint, Edisto is quite vigorous, resistant to alternaria and powdery mildew and tolerant to downy mildew. It also yields well when grown on fertile soil. The South Carolina cantaloupe industry has been saved by the introduction of this variety.

36. *CaroGold, A New Sweet Potato Variety.*

Fusarium wilt has caused a sharp decline in sweet potato production in recent years. CaroGold, a new wilt resistant variety, was released by the South Carolina Agricultural Experiment Station in 1957 in an effort to combat this disease.

In addition to its superior wilt resistance, CaroGold combines high yielding ability with excellent baking quality. Highly desirable orange flesh color, golden skin color and excellent smoothness are further major attributes of this variety. Caro-Gold has been well received by both growers and consumers and present indications are that it will become a standard variety for South Carolina.

37. *Prepackaging of Fresh Vegetables.*

Transparent films are being used extensively in the packaging of fresh vegetables in consumer sized units. The requirements for films used vary widely, depending on what is to be packaged and the conditions which the produce will undergo from the packager to the consumer.

A South Carolina producer was confronted with a serious problem involving detrimental color changes in packaged greens. A study was made of the produce composition and the respiratory gases involved. Based on this information, films with different porosities were recommended. The producer stated that this recommendation resulted in a saving on the produce for the rest of the season of several thousand dollars. In a season, this saving would be much greater.

Prepackaging may be a convenience and/or a virtual necessity in order to insure a fresh product at the Retail Store. Prepackaging can increase profits and with proper management, sales will increase, waste is reduced, and the entire operation becomes more economical. This could mean a saving of many thousands of dollars to South Carolina consumers.

38. *Studies in Peach Processing.*

Research in the Horticultural Processing Laboratory has resulted in several accomplishments which will encourage processing of fruits and vegetables in South Carolina. Two of these accomplishments are a mechanical peach pitter, and evaluation of peach varieties for baby food manufacturing.

A mechanical peach pitter has been developed for freestone peaches. This pitter has a capacity of 100 bushels per hour in contrast to hand pitting when the rate is about 3 bushels per hour per worker.

A baby food manufacturer has established a manufacturing plant in this area, and will soon start processing peaches and other crops from South Carolina. Research has shown that there are several good varieties of peaches which are well suited to the production of baby food purees.

There is a great potential for processing more peaches in South Carolina. The crop is now four to five million bushels annually. If a million bushels of peaches were pitted on the mechanical pitter, the labor saving would be approximately 20 cents per bushel or $200,000-.00. (Currently, approximately 500,000 bushels are processed in South Carolina.)

If a million bushels of peaches were processed within South Carolina, the value to the farmer would be $1,500,000.00, labor to process these would be $1,000,000.00, and the value of the finished product as baby food would be $5,000,000.00.

39. *Promising New Grapes Developed.*

Two selections of bunch grapes show promise as juice grapes. Taste panel tests indicate a preference for these over Concord. They resulted from a cross of S. C. 4707 (Alden x Ellen Scott op. p) x Fredonia. Their parentage includes *V. linsecomii* for vigor and longevity; *V. labrusca,* for disease resistance, size and vigor; and the *V. vinifera* species for its excellent fruit qualities.

A third selection from this cross is a late dessert grape with large berries up to one inch in diameter. It also offers possibilities for juice production. Grape production for juice offers an outlet for some land and labor seeking a replacement for reduced cotton allotments. A $250,000.00 juice plant is being constructed in the Piedmont area of South Carolina to process grapes.

40. *Peach Insect Control in South Carolina.*

South Carolina is the largest shipper of fresh peaches in the United States and one reason for this expansion has been the development of an adequate insect control program. Prior to 1949, insects threatened the peach industry in this state. With the development of parathion the South Carolina Experiment Station pioneered in peach insecticides. The development of parathion as a control for the major insect pests on peaches has resulted in several millions of dollars of additional income to the peach growers in South Carolina.

Probably the number one insect pest of peaches at the present time is the peach tree borer. Although parathion used in three applications has given fair to good commercial control, this appears to be one area where the cost of peach production can be lowered if a material can be found which will do the job with a single application. Continued research has shown that probably hexachloro-hexahydro-methano-2, 4, 3-benzodioxathiepin oxide (Thiodan) will do the job. If this material continues to perform as well as it has in experimental tests, it should save the peach growers in South Carolina another estimated one-half million dollars annually.

41. *The Control of Animal Parasites with Systemic Insecticides.*

For a long time there has existed a need for a more effective method of controlling the external parasites on domestic animals. Probably

the most urgent need is a satisfactory control for the cattle grub. Developments during the past few years indicated that the answer to this problem was to be found in the group of new chemicals known as the organic phosphate esters. Experiments with this group of chemicals showed that certain of these organic phosphate esters exhibited systemic action and were safe to animals. Through the screening and developmental process at several laboratories, two materials were developed to the extent that they are recommended and available to the public for use as systemic insecticides for the control of the cattle grub. Either of these materials when administered according to direction will give better than 95 per cent control of cattle grubs without danger to the animal or to the consumer of the meat.

The cattle grub harms an animal by migrating through the tissues causing irritation and nervousness. Their subsequent cutting of breathing holes damages the most valuable part of the hide. Recent investigations have shown that an animal free of grubs will on an average bring $4.00 more than an infested animal. Considering that South Carolina has over 400,000 head of cattle, this amounts to approximately 2 1/5 million dollars increase to the ranchers of this state.

42. *Chemical Control of the Maize Billbug.*

The maize billbug is a serious pest of corn in the coastal plains area of South Carolina. Prior to 1950, the only known control was crop rotation, and at best, this method was only partially effective. Starting in 1950, experiments were conducted with the newer chemicals to develop a practical chemical control for this pest. The data from these experiments showed that the billbug could be satisfactorily and economically controlled by chemicals, particularly aldrin.

43. *Wireworm Control.*

Although the entomologists have made great strides in developing a control program for the major insects attacking tobacco, probably the greatest advances have been made in the control of the wireworms that attack newly set plants. Entomologists employed by the USDA and the State of South Carolina have developed an effective and economical chemical control for this pest. The control consists of using a small amount of insecticide in the transplant solution.

It is estimated that wireworm control has increased the annual return to the tobacco growers in South Carolina by at least $2,000,-000.00.

In addition to developing an effective control measure, the entomologists have developed an adequate method of surveying for this pest. This means an additional saving to the grower since he can select non-infested fields for planting and eliminate the expense of having to treat.

44. *The Boll Weevil.*

Entomologists in South Carolina and the other cotton growing states have made far-reaching discoveries during the past several years in the control of the boll weevil, but this insect remains the most expensive insect to the agricultural economy in South Carolina. The development of effective control programs using the newer organic insecticides has yielded returns of 25 to 30 million dollars annually to the cotton growers in South Carolina. Although these figures are impressive the cotton growers in South Carolina continue to lose an additional 25 to 30 million dollars annually to this pest.

45. *The Relationships of the Fusarlum Wilts.*

The Fusarlum wilts of many crops are among the more important plant diseases in South Carolina. They attack tobacco, cotton, cowpeas, watermelons, sweet potatoes, soybeans, tomatoes, alfalfa, and many other crops.

Studies at Clemson over the past 25 years have indicated the interrelationships of these various wilt fungi. For example, the fungus which attacks tomatoes appears to be specific to tomatoes. On the other hand, a single fungus has been found to attack both tobacco and sweet potatoes. All of the wilts appearing in South Carolina and most of those in the world have been studied in the greenhouse at Clemson.

Two major benefits have been derived from these studies. From an immediate practical standpoint, it is now possible to recommend crop rotations which will permit growers to avoid many of their wilt problems. As an example, it is indicated that tobacco and sweet potatoes should not be planted in the same rotation. This type of information has been of great value to Agronomists and Horticulturists in working out effective crop rotations for the growers of South Carolina. From a fundamental scientific standpoint, a new concept of the relationships of these fungi has been developed. Earlier and less widespread studies had indicated that these fungi were specific, each to its own special host, and that the various forms may be identified easily by determining which plant they will attack.

46. *Control of Weed in Small Grains and Pastures.*

The problem of broadleaf weeds in small grains and pastures has always been acute. At the end of World War II, when 2, 4-D and related growth regulating chemicals became available, intensive efforts were made simultaneously in South Carolina and many other states to use these chemicals as a solution to this weed problem.

The problems pertaining to the use of 2, 4-D were worked out rapidly. In fact, the pressure for information from growers was so great that research personnel obtained much of their early information from the practical experience of growers. Within a few years, the numbers of mustard contaminated grain fields and bitterweed contaminated pastures were reduced sharply. With present information, certain troublesome weeds, such as bitterweeds in Piedmont pastures, may be completely eliminated by a single application of a chemical costing less than fifty cents per acre.

This development of the methods of use of 2, 4-D which was accomplished simultaneously in many states, probably represented one of the major agricultural developments of the postwar period. It is of especial importance in South Carolina because of the rapid expansion of the livestock industry and the resulting need for feed for these livestock.

47. *Honey Dew Melons as a Crop for South Carolina Farmers.*

Honey dew melons are a luxury crop which has never been produced successfully in South Carolina because of the ravages of various diseases. A disease control program was developed at the Edisto Experiment Station so that it now appears that the melons can be produced economically.

The value of this work cannot yet be determined, since the project is still in the experimental stage. It appears, however, that the honey dew melon may represent a good cash crop for a relatively small number of growers who can handle the tedious and expensive disease control program which has been found necessary.

48. *Chemical Control of Peach Nematodes.*

Nematodes, chiefly the root knot nematode, have always been of concern to peach growers in South Carolina. The recent expansion of the industry into the lighter sandy soils of the coastal plain has resulted in the nematode problem becoming much more acute. Root knot reduces annual yields and also cuts short the bearing life of affected trees.

Research into the control of these nematodes with chemical nematocides is still in progress, but preliminary data, which enable peach growers to avoid the problem at least initially, have been obtained and published. Dosage rates, methods of application, and materials for effective control have been worked out. Tests have been conducted both with pre-plant and post-plant applications of the chemicals.

Since it is anticipated that root knot will undoubtedly prove to be the major disease factor which might limit peach production in the Coastal Plains area, the development of an effective control program will undoubtedly mean the difference between profit and loss in many orchards.

49. *The Determination of the Nature of Oat Yellows.*

Oat yellows has, within the past few years, caused serious losses in oats, primarily in Piedmont, South Carolina.

Research at Clemson within the past 3 years has determined at least one cause of the disease, a fungus of the genus, Helminthosporium. This information, plus that obtained from field and greenhouse tests, has indicated that the disease may be controlled at least partially by crop rotation, seed treatment, and the use of the less susceptible varieties. Thus, within a span of three years after the initial recognition of the problem, at least one cause has been determined and preliminary control recommendations have been made.

The losses from yellows in South Carolina in the 1959 crop were estimated at approximately 2% of the crop or between $200,000.00 and $300,000.00. This would appear to be a relatively small loss if spread uniformly over the state as a whole, but the losses were concentrated in certain areas mostly in the Piedmont, where losses in certain fields have been almost complete.

50. *Use of Feather Meal and Poultry Meat Scraps.*

The 1.4 billion pounds of by-products from the U. S. poultry industry were a burdensome waste until research showed that properly processed feathers and offal were satisfactory sources of dietary protein for poultry. Much of the work showing the value of these products was done by the Clemson Poultry Department.

The approximately 20 million pounds of by-products produced in South Carolina are worth about 1 million dollars as feed for the poultry industry. A troublesome waste has thus been turned into a valuable product through research.

51. *Antibiotics and Egg Production.*

Egg production of chickens was improved by the addition of tetracycline antibiotics to their feed. Production was especially enhanced by antibiotics when birds were infected with the common disease CRD.

An increase of only 2% in egg production among the 4 million hens on South Carolina farms would increase production by 16 million eggs valued at approximately $500,000.00. It is believed that the production of flocks maintained under sub-optimal conditions would be improved by considerably more than 2%.

52. *Dehydrated Coastal Bermudagrass as a Satisfactory Source of Xanthophyll for Egg Yolk Pigmentation.*

Alfalfa meal is used in laying diets as a source of xanthophyll for egg yolk pigmentation. The alfalfa is produced in the midwest or far west and transportation costs to this area are excessive. The demonstration that properly processed Coastal Bermudagrass can be used to replace alfalfa in laying diets makes it unnecessary to import alfalfa.

Between 5,000 and 10,000 tons of alfalfa meal are used each year in laying diets in South Carolina. The demonstration that Coastal Bermudagrass can replace alfalfa provides an opportunity for reduction of feed costs to poultrymen. In addition a market is provided for the abundant Coastal Bermudagrass in South Carolina. The acceptance of Coastal Bermudagrass as a replacement for alfalfa will be dependent upon the production of a uniform high quality product.

53. *Incidents of Experimental Massive Internal Hemorrhage of Turkeys Affected by Dietary Components.*

A synthetic toxin causes massive internal hemorrhage in turkeys when fed at low levels. The lesions produced in this manner are identical to those seen in the widespread disease seen under commercial conditions. Evidence indicates that the field disease is not caused by this toxin, but it is a useful research tool. The dietary level of vitamin B6, fat and certain proteins affect the incidence of internal hemorrhage.

The massive internal hemorrhage of turkeys is a costly problem although the amount of the loss is difficult to estimate. This research suggests that changes in feed formulation will reduce losses from the malady. Research is still in progress in this area.

54. *The Effect of Parallel Terraces on Erosion Control, Irrigation Layouts for Labor Studies and Mechanization.*

Parallel terraces can be used to reduce short rows and increase efficiency of mechanization.

Machine efficiency was increased in all field operations of mechanized corn production in parallel terrace system. The increase in efficiency was due to having all long rows with less curvature and to a reduction in the point row area in the parallel system.

Sprinkler irrigation labor requirements for corn irrigation were reduced from 4.14 man hours per acre in conventional terraces to 3 man hours per acre in parallel terraces.

55. *Shallow Drainage Channels Practical.*

Shallow drainage channels of more than one and a half feet deep with 8.1 side slopes and land farming can replace conventional ditches and be more easily maintained in many of the Coastal Plain Sections of South Carolina. These field ditches provide adequate surface drainage and allow greater mechanization of row crops.

When channels were placed 200 feet apart instead of the usual 100 feet distance, there were no decreases in yield. By eliminating one ditch every 200 feet, four additional rows are gained. This amounts to an increase in available land of six per cent. Since the channel can be maintained with conventional farm equipment a considerable savings in labor can be realized.

56. *Control of Introduced Pests.*

Due to the large number of insects that are known to be present in South Carolina the layman is inclined to think that there are no more pests to invade the state. Nothing could be further from the truth. Each year the quarantine officials collect several thousand species of insects that are not known to occur in the United States; also there are many pests; *e. g.,* gipsy moth, pink bollworm, khapra beetle, etc., in the United States that do not occur in South Carolina. There are others that have invaded South Carolina, but at the present infest small areas. Some of these insects are the white-fringed beetle, Japanese beetle, sweet potato weevil and the imported fire ant.

The South Carolina State Crop Pest Commission in cooperation with the United States Department of Agriculture has accomplished a great deal during the past few years in controlling or containing these pests.

The sweet potato weevil has been contained in the non-commercial potato growing area around Charleston and Beaufort; thereby protecting the 4 to 6 million dollar sweet potato industry in this state.

All known infestations of the white-fringed beetle and the imported fire ant in South Carolina have been brought under control by use of granular insecticides. The entomologists in South Carolina pioneered in the use of this formulation of insecticides for the control of soil infesting insects. Should either the white-fringed beetle or the imported fire ant become spread over the state of South Carolina, it would be necessary for our farmers to expend approximately 1 ½ to 3 dollars per acre annually as a preventative control measure against these pests. This would run into many millions of dollars.

The Japanese beetle first invaded South Carolina in the early thirties, but these sporadic infestations were eradicated and it was not until 1956 that this pest gained a definite foothold in the state along the North Carolina line. The area that is infested is very small and there are hopes that this pest can be brought under control before it spreads over the state. This pest could prove to be as costly as the boll weevil to the agricultural economy of this state.

Stoddard

Campbell

Quattlebaum

Pennington

McCabe